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Contents

Evaluation of the Bioactivities of Plant Extractions from Lavandula stoechas L. and Phlomis syriaca Boiss on Some Pathogenic Microorganisms Isolated from Local Fresh Red Meat
Zeinab Hassan Al-Helwany, Ahd Abo yones, and Adnan Ali Nizam 1

The Use of Alpha-Lipoic Acid as Adjuvant Therapy in Breast Cancer Patients: Quasi Experimental Study
Nancy Yacoub Nashwan, and Mahmoud Hussein Taleb 8

A Prediction Model of Newly Admitted Students in the Level Exam Using Data Mining
Yousef Saleh Abuzir, Isam Younis Amro, Bassam Tork, and Maher Issa..... 23

Diallel Analysis and Heritability of Fruit Quality Traits in Melon (Cucumis Melo L.) Inbred Lines
Hesham Fuzat Alatwani, Faten Mamdouh Alsafadi, Abdel Mohsen Khalel Marie, and Ramzi Fahed Murshid 36

Market Information System for Farmers
Yousef Saleh Abuzir, Waleed Awad, and Mohamad Hamdi Khdair..... 45

Generation of Multiple Frequency Pulse Width Modulation Signals Using FPGA
Samer Jaloudi..... 63

Developing a Smart IoT based Traffic Management System
Yousef Sabbah, Mr. Mohammad Abu Qare', Nizar Barakat, Jameel Sayed, Mohammad Fawaz Salmiyeh, Yousef Salameh, Salah Baddwan, Ahmad Al-Najjar, and Ihab Hamdan 75

Evaluation of the Bioactivities of Plant Extractions from Lavandula stoechas L. and Phlomis syriaca Boiss on Some Pathogenic Microorganisms Isolated from Local Fresh Red Meat

تقييم الفعالية البيولوجية للمستخلصات النباتية لنباتي (الضَّرْمُ المكور) Lavandula stoechas و(الأذينة) السورية Phlomis syriaca على بعض الكائنات الدقيقة الممرضة المعزولة من اللحوم الحمراء المحلية

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ABSTRACT

Plant extracts have become increasingly important additives in the food industry because of their anti-microbial capacity in processed meat products due to their natural origin. They are an excellent candidate to replace synthetic molecules, which are generally considered to have toxic and carcinogenic effects. The effective extraction of these antioxidant molecules from their natural sources and identifying their activity in commercial products is a major challenge for researchers and contributors to food processing. Pathogenic bacteria were isolated from red meat and study the effect of water extracts of L. stoechas and Phlomis syriaca plants in different concentrations on pathogens. The application of plant extracts to improve shelf life and nutritional and health characteristics of red meat products. The activities of the water extracts of the L. stoechas wild plant on the bacteria isolated from meat. The water extract of the L.stoechas plant, with a concentration of 1%, showed positive results on all bacteria ranging between 11 and 15 mm. The sensitivity to the Klebsiella extract seemed higher than other bacterial strains, where the inhibition halo was 15 mm in diameter. In contrast, the Listeria was resistant to the Lavandula water extract with concentrations of 0.5 and 0.25%. The 1% concentration of the water extract of the Phlomis syriaca also showed positive results on all bacteria ranging from 10 to 15 mm. The sensitivity of the Pseudomonas aeruginosa, shigella and salmonella appeared high in terms of the extract compared to other bacterial strains. The halo of inhibition was 15 mm with a concentration of 1% of the water extract. For the Phlomis syriaca, Listeria, Escherichia coli, Pseudomonas aeruginosa, and Staphylococcus aureus were resistant to the water extract of the Phlomis syriaca at a concentration of 0.25%.

Keywords: Wild plants, Lavandula stoechas, Phlomis syriaca, red meat, water extracts, pathogenic microbes.

الملخص

تستأثر المستخلصات النباتية بأهمية متزايدة كمضافات مهمة في صناعة المواد الغذائية؛ بسبب مقدرتها المضادة للجراثيم في منتجات اللحوم الجاهزة للأكل، فهي مرشحة ممتازة لتحل محل الجزيئات المُصّنعة ذات التأثير السام والمسرطن، وكان الاستخراج الفعال لهذه الجزيئات المضادة للأكسدة من مصادرها الطبيعية إلى جانب تحديد نشاطها في المنتجات التجارية يمثّل تحدّياً كبيراً للباحثين والمساهمين في التصنيع الغذائي. تم عزل الأحياء الدقيقة الممرضة من اللحوم ودراسة تأثير المستخلصات المائية لنباتي الضرم المكور والأذينة السورية بتراكيز مختلفة على الأحياء الدقيقة الممرضة. نشاطات المستخلصات المائية لنبات (الضرم المكور L.stoechas) البرية على الجراثيم المعزولة من اللحوم الحمراء ، حيث أبدى المستخلص المائي لنبات (الضرم المكور) بتركيز (1%) نتائج إيجابية على الجراثيم جميعها تراوحت بين(11 و 15 مم) وبدت حساسية(الكلبسيلة Klebsiella) عالية للمستخلص مقارنة بالسلالات الجرثومية الأخرى حيث بلغ قطر هالة التثبيط (15 مم)، في حين أبدت الليستيرية Listeria مقاومة للمستخلص المائي للضرم بالتركيزين(0.5 و0.25%). كما أظهر التركيز (1%) للمستخلص المائي (للأذينة) السورية نتائج إيجابية على الجراثيم تراوحت بين (10 و15 مم)، وبدت حساسية الزائفة الزنجارية والشيغلة والسلمونيلة عالية للمستخلص مقارنة بالسلالات الجرثومية الأخرى، وبلغ قطر هالة التثبيط (15 مم) بتركيز (1%) للمستخلص المائي للأذينة السورية، وأبدت الليستيرية والإشريكية القولونية والزائفة الزنجارية والعنقوديات الذهبية مقاومة للمستخلص المائي (للأذينة) السورية بتركيز (0.25%). تطبيق المستخلصات النباتية لتحسين مدة الصلاحية، والخصائص الغذائية والصحية لمنتجات اللحوم الحمراء.

الكلمات المفتاحية: الفصيلة الشفوية، الضرم المكور، الأذينة السورية، اللحوم الحمراء، المستخلصات المائية، الجراثيم الممرضة.

INTRODUCTION

Food poisoning is one of the most common causes of disease and death in developing countries (Doughari and Pukuma, 2007; Pirbalouti A. G. *et al.*, 2010; Sapkota R. *et al.*, 2012) due to contamination with gram-negative bacteria, such as *Salmonella typhi and Escherichia coli, Escherichia coli, Pseudomonas aeruginosa* (Solomakos N et al., 2008; Pandey A., Singh P. 2011), and Gram-positive bacteria, such as *Staphylococcus aureus and Bacillus cereus*.

However, preservative chemicals can be used to prevent bacterial growth and prevent food spoilage (Yamamura A et al., 2000). The control of food-borne pathogens requires the use of various preservation techniques in the manufacture and storage of food products. Therefore, there is an increasing need for active

preservatives that can prolong product life, inhibiting non-salt microbial growth and sugar, which the consumer prefers at low levels (Zink, 1997). The negative perception of synthetic food additives and the emergence of negative side effects in health led to the development of natural alternatives and the use of extracts pate and oils antibacterial agents, which are safer and more active (Bialonska D et al., 2010, Tajkarimi M. M. et al., 2010; Hussain M et al., 2018).

On the other side, essential oils or their components have antibacterial properties (Oussalah M et al., 2007), parasites (George et al., 2009), viruses (Astani A. et al., 2011), fungi (Silva F et al., 2011; Tiemersma et al., 2011) and antifungal agents. However, the use of vegetable oils and extracts as food preservatives requires knowledge of their Minimal Inhibition Concentration (MIC).

Meat products are oxidized, especially when stored. Mincing facilitates the interaction of oxidants with unsaturated fatty acids and the formation of free, which negatively affects color, flavor, texture, and food quality (Vaithiyanathan S et al., 2011). Fortunately, the application of antioxidants prevents fat oxidation (Martinez-Tome et al., 2001), and plants are of great importance as natural additives (Lindberg, Bertelsen 2011; Zheng and Wang, 2001).

RESEARCH PROBLEM

There is a lack of local studies on wild plants, despite their spread in different Syrian environments. It hinders efforts in determining the extent of the effect of their extracts on pathogenic or non-pathogenic bacteria. It also afflicts the utilization of plant compounds as substances with biological effectiveness and as alternatives to biological antibiotics.

RESEARCH SIGNIFICANCE

Natural alternatives are important for preserving food, such as plant extracts and essential oils with their anti-microbial properties that have a negative effect on food composition and their nutritional quality. Therefore, studying the effect of Syrian lavender and atrium as meat preservatives, preventing microorganism corruption or transfer to pathogens, and prolonging their storage is of great importance.

RESEARCH AIMS

The aim of this research is to identify the anti-aqueous activity of L. stoechas plants and Phlomis syriaca on some bacteria isolated from red meat and preserve them as bioactive and alternative substances for antibiotics and synthetic chemicals.

MATERIALS AND METHODS

Plant Materials

The samples of the L. stoechas and Phlomis syriaca selected for the research were collected in the village of Qismin from the North Kabir area below Tishreen Lake, west of the riverbed at an altitude of about 100-170 m above sea level, 20 km northeast of Lattakia and north of Aleppo road. The sample was sent to the laboratory, washed with sterile distilled water, and then dried on filter paper at 25°C.

L. stoechas, in Figure 1, belongs to the oral family Oblige letter, a herb that spreads in the Mediterranean and the Black Sea areas, on sunny slopes and favors silicic soils. It does not grow in the shade and is relatively tolerant to drought. It is a small branched shrub of 30-50 cm long and has flowers. In general, the coronets are purple, flowering from February to May (ACSAD, 2012).

Figure 1. Lavandula stoechas L.

The Syrian atrial plant *Phlomis syriaca*, Figure 2, belongs to the oral family. This genus' species home is the Mediterranean basin and from Central Asia to China. The flowers are yellow or violet and bloom during the period from April to June. Various studies have indicated the medicinal value of the plant. It enhances the protection of the liver, kidneys, bones, heart, and blood vessels. It is also antibacterial, anti-allergic, and has antioxidant properties (Demirci et al., 2008).

Figure 2. Part of *Phlomis syriaca* Boiss

Preparation of Plant Extracts

Aqueous extracts

Previously dried leaves were placed in the incubator for two hours at 37°C to eliminate any moisture in the sample for easy grinding of the leaves (Blazekovic et al., 2011). The dry leaves were ground with an electric grinder, 25g of the powder was taken and soaked in a 500ml flask with 250ml of distilled water (Khayyat et al., 2018). The samples were placed in the shaker at 170 rpm at laboratory temperature (25°C), away from light for 48 hours (Mahmoudi et al., 2014). The extract was filtered using a 0.45 Watman filter paper and dried in an air incubator at a temperature not exceeding 40°C.

Isolation of pathogens from red meat

The researchers took 10 samples of lamb and 10 samples of veal, Figure 3. Ten grams of each sample were added to 100 ml of sterile peptone, then mixed for 3 minutes at high speed, from 10-1 to 10-4, after they have compiled the analysis of the Hungarian neighborhoods (i.e., vaccination).

Pathogenic microorganisms were isolated from meat samples and a selection of selective solid bacterial media was taken, such as EMB Agar for Enterobacter development, Chapman Agar for staphylococcal development, and CetramideAgar to characterize Pseudomonas aeruginosa Editing ammonia, Agar PDA Dextrose Potato medium for the development of Candida albicans, as well as nutritious agar medium and nutrient broth (APHA, 2000). Bacteria isolated from the samples could be classified after conducting the necessary biochemical tests (oxidase, catalase, indole, methyl red, citrate fermentation, VogsProscaur, H2S release) based on the Bergi evidence (Garrity G. M et al., 2005).

Figure 3. Lamb and veal samples

Furthermore, the sensitivity and resistance of isolated microbes were tested by the propagation method of tablets. The sensitivity and resistance of some antibiotics were determined by measuring halos inhibitors on Mueller Hinton Agar's medium (Barker and Kehoe E, 1995).

A group of antibiotics was used (Table 1) with a concentration in the tablets.

Table 1Used Antibiotics, mcg.

Antibiotc	Code
Ampicillin/ Cioxacillin	APX: 25/5 mcg
Lincomycin	L:2 mcg
Erythromycin	E:15 mcg
Cefaclor	CEC: 30 mcg
Pipemidic	PI:20 mcg

Preparation of bacterial inoculum

The activation of activated microbes was carried out on the Nutrient Agar NA and incubated at 37°C for 24 hours. Ten colonies of each type of bacterium were transferred, under sterile conditions, to a test tube containing 5 ml of broth nutrients. At 37°C for 4 hours, appropriate dilutions were carried out for each type of bacterium, with a total cell count of 1.5 x 8^{10} cells/ml (Anandiand Juan, 2009).

Test of anti-microbial Bioactivity of Plant Extraction

Aqueous extracts were prepared at a concentration of 0.25, 0.5, 0.75, and 1.0%. Muller-Hinton medium was prepared by dissolving 38 g of it in a liter of distilled water, with 0.5 ml of bacterial suspension, and brushes were transferred over the culture medium with a cotton swab. After 15 minutes, the extracts were distributed and placed in the fridge. The incidence of inhibition zones is evidence of bacterial growth inhibition, and their diameters are measured after finishing

the lap with a precise measuring instrument or millimeter ruler. The experiment was performed with three replications (Kelmanson et al., 2000).

RESULTS AND DISCUSSION

The Effect of Dry Extracts of *Lavandula stoechas* L. and *Phlomis syriaca*

The results shown in Table 2 showed that the *L. stoechas* plant contains 22.98% of the pure extract of aqueous extract. In comparison, the *Phlomis syriaca* plant contains 21.11% of the pure extract.

Table 2 The Yield of Dry Plant Extracts Used in the Research.

Plant	the sample	Repeater% 1	2	3	Average and deviation
Lavandula stoechas	25	23.56	22.4	22.98	22.98 ±0.58
Phlomis syriaca	25	20.5	21.73	21.11	21.11± 0.61

Bacterial species isolated from meat

Table 3 shows the six isolated bacterial species when testing red meat microbiologically and one type of yeast *Candida albicans.* See the *Pseudomonas aeruginosa*, *E.coli* in Figure 5, the *Klebsiella* in Figure 4 and the *Shigella* (Table 3).

Table 3 Microorganisms Isolated from Red Meat from Different Areas in Homs

Microbe strain	Rate of positive samples in meat% Sheep meat	veal
E. coli	85.71	66.66
Pseudomonas aeruginosa	57.14	33.33
Klebsiella sp.	42.85	16.66
Shigella sp.	28.57	50.00
Salmonella sp.	42.85	33.33
Staphylococcus aureus	14.28	66.66
Candida albicans	28.57	16.66

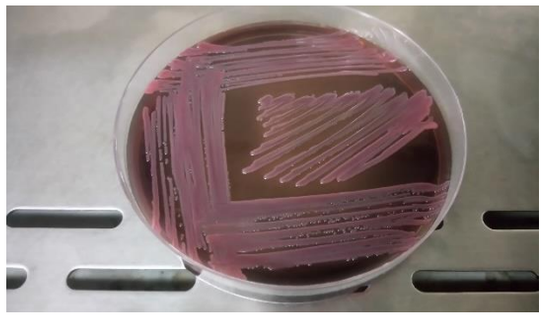

Figure 4. *Klebsiella* on EMB

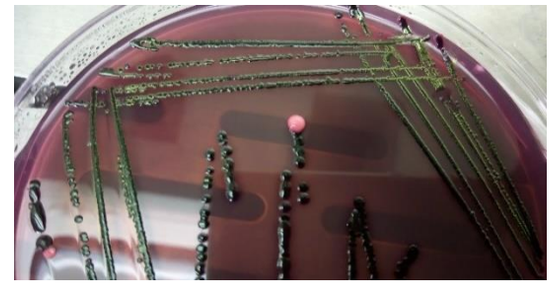

Figure 5. *E. coli* on EMB

Biological activity of L.stoechas plant extracts on pathogenic microorganisms.

Table 4 shows the results of the study of the biological activity of water extract of the L. stoechas against germ

Table 4 Diameter of Halo Inhibition of Aqueous Extract of the Wild Plant L. stoechas for Tested Germs and Candida albicans, per mm

Microbe strain	Average halo inhibition diameter,% 0.25	0.5	0.75	1.0
E. coli	0.0 ± 7	9 ± 0.0	12 ± 1.0	14 ± 0.57
Pseudomonas aeruginosa	6 ± 0.0	10 ± 1.0	11 ± 0.57	13 ± 1.0
Klebsiella sp.	-	8 ± 1.52	12 ± 0.0	15 ± 1.52
Shigella sp.	-	09 ± 1.0	11 ± 0.57	12 ± 2.08
Salmonella sp.	6 ± 1.0	8 ± 0.57	12 ± 0.57	14 ± 1.52
Staphylococcus aureus	7 ± 1.0	9 ± 0.0	12 ± 1.0	13 ± 0.0
Listeria sp.	-	-	9 ± 1.0	11 ± 0.0
Candida albicans	7 ± 0.57	10 ± 1.0	11 ± 0.0	14 ± 0.0

Moreover, the concentration of 1% showed positive results on all bacteria ranging from 11 to 15 mm (Figure 6). The klebsiella sensitivity of the extract was high compared to other bacterial strains. The inhibition of 9 mm in concentration was 0.75%, which is consistent with the result of the researchers (Tabatabaei et al., 2014). The maximum value (14 mm) was 1.0%.

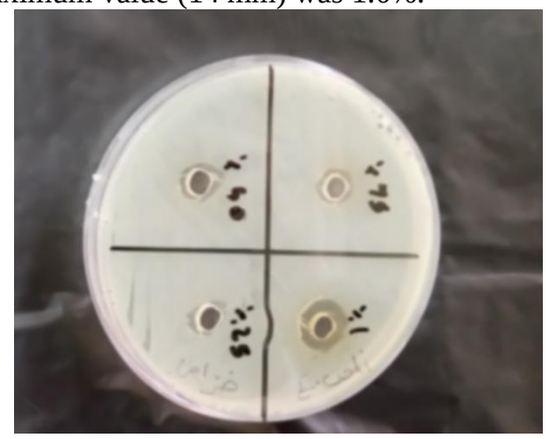

Figure 6. The efficacy of L. stoechas water extract on E.coli

Table 5 shows the results of the study of the impact of the biological activity of the aqueous extract of the *Boiss* against bacteria.

Table 5 Diameter of Halo Inhibition of Aqueous Extract of Syrian Atrial Plant Phlomis syriaca for Tested Bacteria and Candida albicans, per mm

Microbe strain	Average halo inhibition diameter,%			
	0.25	0.5	0.75	1
E. coli	-	7± 0.0	9± 1.0	10± 0.0
Pseudomonas aeruginosa	-	8± 0,57	10± 0.0	15± 1.0
Klebsiella sp.	6± 1.0	7± 1.52	9± 0.0	10± 1.52
Shigella sp.	-	9± 1.0	11 ± 0.57	15± 2.08
Salmonella sp.	06 ± 1.0	8± 0.0	10± 0.57	15± 1.52
Staphylococcus aureus	-	7± 0.0	10± 1.0	12± 0.0
Listeria sp.	-	6± 1.0	8± 1.0	10± 0.0
Candida albicans	6±1.0	9± 1.0	11 ± 0.0	14 ± 0.0

The concentration of 1% showed positive results on all germs ranging from 10 to 15 mm. The sensitivity of Pseudomonas aeruginosa in Figure 7. The Shigella and Salmonella appeared to be high for the extract compared to other bacterial strains. Gold resistance to aqueous extract of the Boiss was at a concentration of 0.25%.

Table 6 shows the results of the sensitivity of the isolated pathogenic bacteria to the tested biological antibiotics. All the bacteria under test were resistant to Ampicillin, Cefaclor, Lincomycin, and Erythromycin.

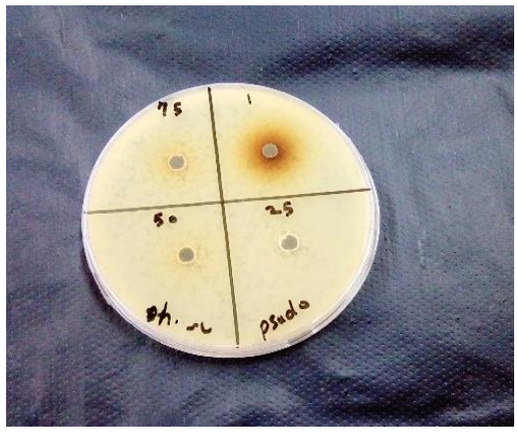

Figure7.The efficacy of *Phlomis syriaca* water extract on *Pseudomonas aeruginosa*

Table 6 Results of Sensitivity and Resistance of Microorganism Strains to Biological Antibiotics, Inhibition Diameter, 1 mm

abbrev. Biological R code	APX	CEC	L	E	PI
conc.	30	30	2	15	20
E. coli	R	R	R	R	6
Pseudomonas aeruginosa	R	R	R	R	9
Klebsiella	R	R	R	R	9
Shigella	R	R	R	R	9
Salmonella	R	R	R	R	8
Staphylococcus aureus	R	R	R	R	9
Listeria	R	R	R	R	20
Candida albicans	R	R	R	R	9
Resistance = R					

The gram-positive Listeria bacteria showed high sensitivity to Tobramycin and Pipemidic, with a damping aura of 16 and 20 mm, respectively. The gram-negative Pseudomonas aeruginosa showed good sensitivity against these inhibitors.

The results show that the aura diameters of aqueous extracts were generally larger than the diaphragms of the biological antibiotics used.

CONCLUSION

1. Aquatic extracts of *L. stoechas* and *Boiss* are anti-microbial agents.
2. The aura diameters of inhibition of aqueous extracts were generally greater than the dampening aura diameters of the antibiotics used.
3. Using plant extracts can be a healthy method and technique for preserving meat.

Botanical extracts are considered beneficial nutrients for health because they contain medicinal compounds

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The Use of Alpha-Lipoic Acid as Adjuvant Therapy in Breast Cancer Patients: Quasi Experimental Study

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ABSTRACT

Oxidative stress plays a major role in the process of carcinogenesis. This fact highlights the questions about the effect of antioxidants in cancer therapy. Alpha-lipoic acid (ALA) has gained a lot of concern in the last decade as an antioxidant in many pathological conditions, including cancer therapy. This study was conducted to identify the effect of ALAwhen used with chemotherapy in breast cancer. The study examined its effect on oxidative stress. We examined Malondialdehyde (MDA) as an oxidative stress biomarker, chemotherapeutic Induced Peripheral Neuropathy (CIPN), chemotherapeutic Induced nausea and vomiting (CINV), dyslipidemia, and renal function. This experimental study was conducted in al-Shefa hospital in Gaza Strip among women who were admitted to the oncology department and diagnosed as breast cancer patients. Fifteen cases were given ALA, 600 mg per day for six months, and 15 control groups in which the MDA, Creatinine and lipid profile were examined at zero time. After 3 months and 6 months, the adverse events were examined by a face-to-face questionnaire to the cases at zero time. The median of MDA was significantly decreased in the first 3 months from 8.4 nmol/ ml to 5.4 nmol (P-value = 0.013). However, after six months, it was not significantly decreased. The median of MDA was 4.6 nmol/ml (P-value = 1). Creatinine was significantly decreased after six months (P-value = 0.000). In contrast, urea was not changed significantly. Concerning the lipid profile TC, LDL was elevated significantly, and HDL was not significantly improved. According to adverse events, CIPN, pain was not significantly improved; only 58% (P-value = 0.07) of the cases stopped feeling pain. Imbalance also was not significantly improved; only 33% of cases stopped feeling imbalanced (P-value 0.125), while 80 % of cases stopped feeling numb (P-value = 0.008). On the other hand, 83% of cases stopped feeling a tingling sensation (P-value = 0.002), and 81% of cases have no trouble in holding things (P-value = 0.004). No patient complained of vomiting after the use of ALA (P-value = 0.00). The use of ALA has a beneficial effect on oxidative stress, which has a major role in the process of carcinogenesis. It has a protective effect on renal functions and a beneficial effect on both CIPN, CINV.

Keywords: Oxidative Stress, Alpha Lipoic Acid, MDA.

الملخص

تلعب الأكسدة دورا أساسيا في عملية السرطنة، وهذا يسلط الضوء على دور مضادات الأكسدة في الحد من هذا الدور، وقد لاقى مركب (الالفا ليبويك أسيد) اهتماما كبيرا في العقد الآخير في كثير من الأمراض المتعلقة بالأكسدة وخاصة في مجال السرطان. أجريت هذه الدراسة في مشفى الشفاء للتعرف على دور مركب (الفاليبويك أسيد) كعلاج مساند للعلاج الكيميائي المستخدم في سرطان الثدي. اختبرت الدراسة تأثير (الفاليبويك أسيد) على الأكسدة المتمثلة بمستوى المالون (داي الدهايد) في الدم. كما تختبر الدراسة تأثير (الفاليبويك أسيد) على الآثار السلبية المصاحبة للعلاج الكيميائي، مثل: الاعتلال العصبي المسبب بوساطة العلاج الكيميائي، والاستفراغ، والغثيان المسبب بوساطة العلاج الكيميائي، وتختبر الدراسة أيضا تأثيره على مستوى الدهون في الدم التي ترتفع في سرطان الثدي. وقد أجريت هذه الدراسة (الدراسة التجريبية). وقد تم اختيار العينة من النساء الذين يدخلون إلى قسم الأورام في مستشفى الشفاء قطاع غزة، ويتم تشخيصهم على أنهم مرضى سرطان الثدي. الحالات تم اعطاؤهم (الفاليبويك أسيد) بواقع حبة يوميا (600 mg)، وتم عمل فحص لمستوى المالون (داي الدهايد) كمؤشر على مستوى الأكسدة عند نقطة الصفر، وتم فحص (الكرياتينين واليوريا) كمؤشر على وظائف الكلى، وكذلك فحص مستوى الدهون. ثم تم إعادة هذه التحاليل بعد ثلاثة أشهر، وبعد ستة أشهر لكل من الحالات والشواهد. وتم عمل استبانة للحالات قبل استخدام (الفاليبويك أسيد) وبعده فيما يخص أعراض الاعتلال العصبي المصاحب للعلاج الكيميائي أعراض الغثيان. أظهرت النتائج فيما يتعلق بمستوى الأكسدة فان قياسات (المالون داي الدهايد) تحسن في وسيطها للحالات في أول 3 أشهر (بدلاله احصائيه0،013) بينما لم يكن نزول المستوى في الوسيط في الثلاث أشهر الثانية لم يكن ذا دلاله إحصائية (دلاله إحصائية = 1) ولم يكن هناك دلاله إحصائية بالنسبة للشواهد (دلاله إحصائية =0،6). وفيما يتعلق بمستوى (اليوريا) لك يكن هناك تغير ذا دلاله إحصائية في كل من الحالات والشواهد، أمّا فيما يتعلق (الكرياتينين) فان التغير فيه كان ذا دلاله إحصائية بعد ستة أشهر (دلاله احصائي =0،003). ولم يكن هناك تحسن في مستوى الدهون، وإنما كان هناك ارتفاع ذا دلالة إحصائية في مستوى (الكوليسترول) في الحالات (دلاله إحصائية = 0،003) فان هناك ارتفاعا، ولكنه لم يكن ذا دلاله إحصائية في كل (م ن LDL)، أما فيما يخص (الكوليسترول) الخبيث لم يكن هناك ارتفاع ذا دلاله إحصائية (HDL) الحالات والشواهد. كذلك (الكوليسترول) الحميد أعراض العلاج الكيميائي تحسنت بدلاله

إحصائية ما عدا الألم، والشعور بعدم الاتزان. ولم يكن هناك تحسن في مستوى الدهون، وإنّما كان هناك ارتفاع ذا دلالة إحصائية في مستوى (الكوليسترول) في الحالات (دلاله إحصائية = 0،003)، وكان هناك ارتفاع، ولكنه لم يكن ذا دلالة إحصائية في كل (م ن LDL)، أمّا فيما يخص (الكوليسترول) الخبيث لم يكن هناك ارتفاع ذا دلاله إحصائية (HDL) الحالات والشواهد. كذلك (الكوليسترول) ا لحميد أعرنض العلاج الكيميائي جميعها تحسنت بدلاله إحصائية ما عدا الألم، والشعور بعدم الاتزان. وخلص البحث إلى أنه توجد تأثيرات ايجابيه لاستخدام (الفا ليبويك أسيد) كعلاج مساند للعلاج الكيميائي تقليل لمستوى الأكسده، سضاف إلى ذلك وجود تأثيرات ايجابية لاستخدام (الفاليبويك أسيد) على وظائف الكلى، وجد تأثيرات ايجابيه (للفا ليبويك أسيد) على الأعراض الجانبية للعلاج الكيميائي توجد تأثيرات ايجابيه للالفاليبويك اسيد على الأعراض الجانبية للعلاج الكيميائي المتمثلة بالاعتلال العصبي واعارض الغثيان والاستفراغ. وأوصى البحث لمقدمي الخدمة الصحية لإقرار استخدام (الالفاليبويك أسيد) كعلاج مساند للعلاج الكيميائي.

الكلمات المفتاحية: مالون داي الدهايد، مفاتيح الكلمات: الاكسده، سرطان الثدي، الالفاليبويك اسيد، ROS,CIPN,CINV.

INTRODUCTION

Cancer is a group of diseases characterized by abnormal and uncontrolled growth and the spread of cells. Anyone can develop cancer, as the risk of being diagnosed increases with age. Most cases occur in adults who are middle age or older. About 78% of all cancers are diagnosed in patients by the age of 55 years and older (Alhams et al., 2014).

Cancer is the second leading cause of death after heart disease worldwide and a major public health problem in the USA and other countries (Seigel et al., 2015).

Cancer begins when cells in a part of the body start to grow out of control. Cancer cells differ from normal cells in that cancer cells will not die. They continue to grow and form new abnormal cells (American cancer society, 2015)

"Breast cancer is a complex multifactorial disease where there is a strong interplay between genetic and environmental factors" (Martin and Weber, 2000).

Eleven million cases of cancer now occur annually worldwide, six million of them in low- and middle-income countries, with around five million deaths from cancer (Alhams et al., 2014).

Epidemiology

There are one million new cases of breast cancer worldwide each year and comprise 18% of all women malignancies, where the age-standardized incidence and mortality are the highest in the UK (McPherson et al., 2000).

One out of nine women in the UK and the USA will develop the disease in their lifetime (Abdulkareem, 2013).

Breast cancer is the most common type of cancer among women. An estimated 232,340 new cases of invasive breast cancer were diagnosed among women in the USA during 2013. Deaths are estimated at 40,030 (American cancer society, 2014).

In Palestine, breast cancer occupied the most prevalent type of cancer (31.4%, about 45% in Gaza strip), followed by colorectal (9.2%), and then trachea and bronchus (5.5%) (Al hams et al, 2014).

According to mortality, breast cancer occupies third place after colorectal (second) and lung (the first) in Gaza Strip and West Bank. Breast cancer was known to be the first leading cause of death among females (21.1%) (Al hams et al, 2014).

In Gaza strip breast cancer prevalence rate is 149.1/100000, the number of all breast cancer cases in female is 1207 which represents 31.1% of all female cancer cases. The maximum level of cases is 317 cases in the age group 55 – 64 (Palestinian Health information centre,2015).

Treatment

Local Treatment

Surgery may vary from local excision or segmental mastectomy and breast conservation for masses less than 4 cm in diameter. For simple mastectomy, the choice is taken according to the breast mass location and extent in relation to the breast size and the patient's preferences. Surgery of the axilla is by sentinel lymph node guided sampling (after dye injection) (Kumar and Clark, 2009).

Her2 therapy (Kumar and Clark, 2009).

Adjuvant systemic treatment-This is divided into four lines:

Chemotherapy

- AC/EC – doxorucin or epirupcin and cyclophsphamide
- DC- docetaxol and capicitabine
- PG-paclitaxel and Gemicitabine
- VC- vinorelbine and cabcitabine (Kumar and Clark, 2009).

A third-generation regimen with a taxane (AC-T) cyclophosphamide, adriamycin, taxane (Kumar and Clark, 2009). This regimen is the one that is used in the Gaza Strip as a protocol of therapy. It decreases the relative risk of death by 33% and increases the toxicity (Kumar and Clark, 2009).

Menopausal status does not affect the relative efficacy of chemotherapy. Since the recurrence is less after menopause, the absolute improvement in survival is lower. Toxicity may be higher, so the choice must be individualized to each patient. The combined chemotherapy and radiotherapy and tamoxifen or aromatase inhibitors halve the risk of dying of breast cancer for the appropriately selected patients (Kumar and Clark, 2009).

Apoptosis and Oxidative Stress

Apoptosis (programmed cell death) "Is genetically regulated form of cell death, it has a role in biological processes, including embryogenesis, aging, and many diseases, the molecular mechanisms involved in death signals, genetic regulation, activation of effectors have been identified" (Renehan, 2001).

The genetic basis of apoptosis implies that cell death, like any other metabolic process, can be disrupted by mutation. In fact, defect in the apoptotic pathway is now thought to contribute to a number of human diseases ranging from neurodegenerative disease to malignancy (low and lin, 2000)

Oxidative Stress Definition

"Is a state of where oxidative forces exceed the antioxidant system due to loss of balance between them" (Yoshikawa, 2002).

Effect of Oxidative Stress in the Process of Carcinogenesis

Epidemiological studies indicated that chronic oxidative stresses are strongly associated with carcinogenesis (et al,.2011).

ROS, which results from oxidative stress, can damage critical cellular macromolecules and/or modulate gene expression pathways. Oxidative damage resulting from ROS generation can participate in all stages of the cancer process. An association of ROS generation and human cancer induction has been shown. It appears that oxidative stress may both cause as well as modify the cancer process. Recently, the association between polymorphisms in oxidative DNA repair genes and antioxidant genes (single nucleotide polymorphisms) and human cancer susceptibility has been shown (Klaunig et al,.2011).

Antioxidant

"Antioxidants are responsible for the neutralizing action of these reactive species. As definition, an antioxidant is any substance that, present in low concentrations in relation to the oxidizable substrate, retards or inhibits the oxidation of such a substrate, including enzymatic and non-enzymatic compounds" (Rossi et al, 2009)

Oxidative Stress Biomarker

Oxidative stress biomarker can be defined as "predictive indicators of the development of a pathology able to detect in vivo oxidative damage." Such markers can be subdivided into pro-oxidant and antioxidant, in accordance with the affected system (Rossi et al., 2009)

Malondialdehyde (MDA).

As mentioned before, lipid peroxidation is one of the pathways of oxidation in the body. Lipid peroxidation has an end product called Malondialdehyde (MDA) which is a biomarker. MDA is a naturally occurring product of lipid peroxidation; it can also be generated during prostaglandin biosynthesis in cells (Jetawattana,2005).

Alphalipoic acid (ALA; thioctic acid, 5-(1,2-dithiolan-3-yl) pentanoic acid). It is a naturally occurring antioxidant synthesized in small

amounts by plants and animals, including humans (Dozio et al ,2010)

Alpha-lipoic acid (ALA) plays an essential role in mitochondrial bioenergetic reactions, which has gained attention as a nutritional supplement and as a therapeutic agent. Moreover, LA conjugates with other pharmacophores represent a promising approach toward the development of multifunctional drugs (Maria Koufaki, 2014).

LA exists in the form of two enantiomers, R or S. In physiological condition, LA is present in the form of lipoate with the proton of the hydroxyl functional group substituted by remains of organic alcohol or with an inorganic ion. LA (in the form of lipoate) acts as a cofactor in reactions of aerobic metabolism. It participates in the transfers of acyl and methylamine groups. It is essential for aerobic processes of life and serves as a coenzyme in the Krebs cycle (Novotny et al, 2007).

The common use of ALA is an antioxidant used to treat many neurological disorders such as diabetic polyneuropathy and multiple sclerosis as it can cross the blood-brain barrier. It has been shown to improve endothelial function and blood flow. It accelerates glutathione synthesis, which plays a crucial role in regulating the expression of several antioxidants and anti-inflammatory genes (Choi et al., 2015).

Studies on cancerous cell-based models have suggested that the tumor-suppressive effect of ALA corresponds with apoptosis induction, which is a critical parameter impaired in cancer cells. This induction is selectively exerted in cancer and transformed cells while being less active toward non transformed cells (selvkumar and heish,2008).

However, ALA is soluble in both water and lipids. ALA is highly reactive due to the tension of the S-S-C bond in the heterocyclic disulfide circle. ALA is relatively stable as a solid, but it polymerizes when heated above its melting point (47.5 c; Novotny et al., 2007).

Pharmacological Effect of ALA

Antioxidant effect:

ALA is ROS scavenger and metal chelating the disulfide group of LPA, which can be reduced to DHLPA. Both of them have been reported to scavenge a variety of oxygen species. Additionally, the pharmacological impact of LPA/DHLPA redox couple is due to metal chelating properties (Feuerecker et al,.2012).

It has powerful lipophilic antioxidants both in vitro and in vivo. It is known to act as a scavenger of many reactive oxygen species (ROS). ALA has been proposed as a treatment for oxidative disorders of the nervous system characterized by an increase of free radicals (Ranieri et al., 2010)

Recycling Other Antioxidants

In addition to ROS scavenging, LA has also been shown to be involved in recycling other cellular antioxidants, including vitamins C and E, and glutathione (Biewenga et al., 1997).

Antitumor effect of alpha-lipoic acid exerts antitumor effect by the following mechanisms

Unlike normal cells, tumor cells survive in a specific redox environment where the elevated reactive oxygen species, which play a role in critical signaling molecules, contribute to enhance cell proliferation and suppress apoptosis. The alpha-lipoic acid was able to induce cell cycle arrest and apoptosis in different cancer cell lines (Dozio et al.,2010).

ALA inhibits glycolysis:

Cancer cells perform higher glycolysis rates, i.e., conversion of glucose to lactate instead of complete oxidation of glucose to water and CO2 for the generation of ATP (***Zhang et al.,2015).***

The presence of ALA shifts ATP production by TCA cycle towards oxidative phosphorylation instead of glycolysis in which cancer cells stick, and consequently, apoptosis is inhibited. Feuerecker examined the effect of ALA on human cells; a slight dose-dependent increase of pyruvate dehydrogenase activity was observed ***(Feuerecker et al.,2012).***

Apoptosis induced by LA was found to be mediated through the mitochondrial death pathway, which requires caspase-9 activation death ***(Moungjaroen et al.,2006).***

ALA Prevents Metastasis

In 2010, Lee et al. studied the effect of alpha-lipoic acid in the prevention of metastasis in the cell system. They hypothesized that LA inhibits

metastasis via inhibition of matrix metalloproteinase (MMP) in vitro. The enzyme is responsible for metastasis. MDA-MB-231 cells, a human breast cancer cell line, were treated with various concentrations of LA (0, 250, 500, or 1000 μmol/L) to measure metastasis, MMP activity, and mRNA expression. The viability of cells was examined by the 3-[4,5-dimethylthiazol-2-yl]-2,5-diphenyltetrazolium bromide assay. The effect of LA on metastasis was evaluated using the motility, migration, and invasion assay in vitro. The activity and mRNA expression of MMP-2 and MMP-9 were measured. After LA treatment, cell motility and cell migration were significantly decreased ($P < .05$). The α-Lipoic acid also reduced cell invasion through a Matrigel-coated chamber ($P < .05$). Activities of MMP-2 and MMP-9 were decreased by LA treatment in a dose-dependent manner. The analysis confirmed the reduction in mRNA expression level of MMP-2 and MMP-9 by LA treatment. They concluded that LA treatment inhibits cancer metastasis in this cell culture model, and this inhibition is likely due to the decrease in the activity and mRNA expression levels of MMP-2 and MMP-9 caused by LA ***(Lee et al., 2010).***

Effect on Lipid

Lipid peroxidation, the oxidative deterioration of the polyunsaturated fatty acids (PUFA), leads to the formation of hydroperoxides, short-chain aldehydes, ketones and other oxygenated compounds. This process is considered responsible for the development of various diseases like cancer ***(Zulkhairi et al., 2001).***

Minimizing the Side Effects of Chemotherapy

The effect of alpha-lipoic acid also was investigated against the minimizing of the side effects of chemotherapy. In 2008, Melli et al. studied the neuroprotective effect of alpha-lipoic acid. They used an *in vitro* model of chemotherapy-induced peripheral neuropathy that is closely similar to the *in vivo* condition by exposing primary cultures of dorsal root ganglion (DRG) sensory neurons to paclitaxel, widely used and highly effective chemotherapeutic drugs. This approach allowed the investigation of the efficacy of alpha-lipoic acid in preventing axonal damage and apoptosis and the function and ultrastructural morphology of mitochondria after exposure to toxic agents and alpha-lipoic acid. Their results demonstrated that paclitaxel cause early mitochondrial impairment with loss of membrane potential and induction of autophagic vacuoles in neurons. Alpha-lipoic acid exerts neuroprotective effects against chemotherapy-induced neurotoxicity in sensory neurons. It rescues mitochondrial toxicity. These findings suggest that alpha-lipoic acid might reduce the risk of developing peripheral nerve toxicity in patients undergoing chemotherapy ***(Melli et al.,2008)***

ALA prevents the nephrotoxic effect of Adriamycin; ALA is also capable of influencing the nephrotoxicity potential of adriamycin.

It can help minimize CINV using its antioxidant effect; therefore, it has a beneficial effect on other cells that are harmed by chemotherapy. Mantovani et al. examined the effect of antioxidants on side effects of chemotherapy as fatigue, nausea, and vomiting. All patients were given as basic treatment polyphenols plus antioxidant agents α-lipoic acid, carbocysteine, and vitamins A, C, and E, all orally. After 2 years, no severe side effects, including nausea and vomiting, were observed (***Mantovani et al.,2008).***

METHODOLOGY

- **Materials and Methods**
  - **Materials**
    1) Thiobarbituric acid Kit for measurement of malondialdehyde which was purchased from Biodiagnosteic company – Egypt, and preserved in the refrigerator at 2-8°C.
    2) Alpha-lipoic acid (Neurogaurd ® 600 mg) donated from the Advanced company- Gaza.
    - Biochemical Parameters:
      1- Total Cholesterol TC.
      2- Low-density Lipoprotein LDL
      3- High-density Lipoprotein HDL
      4- Serum urea level
      5- Serum creatinine levels
      6- Lipid peroxide {measured as MDA}
  - **Study Design**

The study conducted a randomized clinical trial study on a population of women diagnosed with breast cancer and admitted to the oncology

department in al-Shefa hospital. The sample was chosen according to specific criteria.

Cases: 15 patients

Eligibility:

Non-pregnant
Non-lactating
Non-metastatic
Under (Adriamycin, cyclophosphamide, Taxol) A CT protocol.

All women were at the beginning of their chemotherapy; the choice was made under the supervision of the head of the oncology department.

The patients were given informed consent.

A serum sample was collected from the patient when admitted for chemotherapy after three months and six months.

The case group was given alpha-lipoic acid, 600 mg once daily for six months.

Control group

Eligibility criteria

Non-pregnant
Non-lactating
Non-metastatic patients
No drug intervention

Blood samples were collected in serum tubes on vacuum without pushing the sample through the needle to avoid hemolysis. All samples were transmitted immediately to the laboratory.

- **Methods**

1- The Kit of MDA is thiobarbituric acid which is chlorometric. Thiobarbituric acid reacts with MDA in acidic media at a temperature of 95 ◦C for 30 min to form thiobarbituric acid reactive

$$\text{Serum MDA} = \frac{\boldsymbol{A\ Sample}}{\boldsymbol{A\ standard}} \times \mathbf{10}\ \boldsymbol{nmol/ml}$$

The blood samples were mixed, and the test tubes, which were covered with glass beads, heated in boiling water bath for 30 min, cooled, then mixed, and the absorbance was read at 534nm.

2- Analysis of serum lipids total cholesterol, LDL and HDL, was analyzed every three months.

3- Urea and creatinine were also analyzed.

All tests were performed in al-Nebrass Laboratory, which is registered by the Ministry of Health.

An abstract sheet was performed to compare the complaint of CIPN pre- and post-medication and compare the number of vomiting per day during chemotherapy.

The face-to-face questionnaire (Yes or No) was performed, asking patients about the side effect of chemotherapy.

Chemotherapeutic Induced Peripheral Neuropathy before and after treatment was performed to measure ALA imbalance, pain, tingling, numbness, and trouble in holding or picking things.

Chemotherapeutic Induced Nausea and Vomiting (CINV):

Patients were asked about the number of vomiting per day before and after treatment with ALA.

- **Statistical Analysis**

Patients were given symbols.

Cases were given letters from (A1 – A15).

Controls were given letters from (B1 – B15).

Descriptive analyses were performed for study data; data were entered into the SPSS program.

Alpha-lipoic acid was given to 15 breast cancer patients who were chosen to be the cases. Neurogaurd drug was given month by month, 30 tablets for each patient, and the patients' compliance was measured individually to ensure taking the drug.

The blood serum of 30 newly diagnosed breast cancer has been analyzed, and MDA, CBC, UREA, CREAT, Cholesterol, HDL, LDL have been measured.

- A repeated-measures ANOVA with a Greenhouse-Geisser correction was used for continuous data.
- Wilcoxon rank test was done for the number of vomiting pre- and post-treatment with ALA.
- QI square (McNemar test) was used to measure the significance of pain, imbalance, numbness, tingling, and trouble in picking or holding things before and after the end of six months treatment.
- The median was taken, and P-value was hypothesized to be statistically significant at 0.05.

RESULTS

MDA For Healthy Individuals

MDA has been measured for 10 healthy individuals to be sure that the normal blood level of MDA is the same as mentioned in previous studies, the mean of MDA was about 2.66nmol/ml.

The healthy individuals were chosen with no other diseases to avoid any elevation in MDA value.

MDA for cases

The MDA for cases was measured at zero time, after 3 months and 6 months; the median was chosen for study values because the sample is small.

The median value of MDA was 8.4 nmol/ ml. After three months of ALA use, the median declined to 5.4 nmol/ ml with a P-value of 0.013.

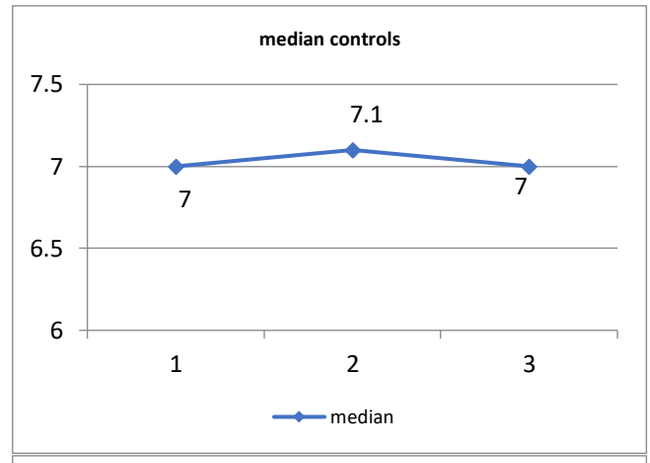
Then after 3 months (six months from the beginning of the study), the median value became 4.6 nmol/ml with a P-value of 1. The significance across time reveals that the first three months were significant while the second three months were not significant.

MDA for controls

The MDA was measured at zero time for controls; the median was 7.1. After three months, it was 7; after six months, no change in MDA median was noticed. It was still the same after six months.

Table 1 Measurement of MDA in Cases and Controls at Zero, After 3 Months and After 6 Months

MDA median	Cases	p-value	Controls	Standard Deviasion cases	Standard deviasion controls	p-value
Zero	8.4		7	3.1995	3.3833	
3 months	5.4	0.013	7.1	2.3789	3.2295	0.6
Six months	4.6		7	3.1806	4.3582	



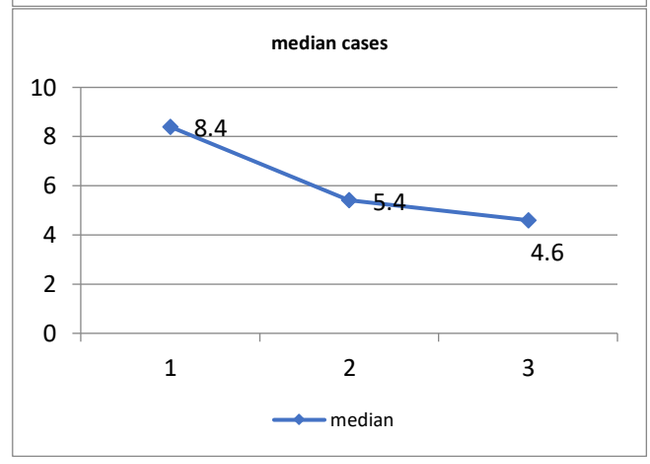


Figure 1 Median of MDA of Cases and Controls vs Time

Urea for Cases

The urea for cases was measured at zero, after three months and after six months, the median after three months was 29 mg/dl, after three months was 30 mg/dl, and after six months was 31 mg/dl. The urea was not significantly affected by the use of ALA.

Urea for Control

Urea for controls was measured for urea at zero, three, and six months. At Zero, the median was 26 mg/dl; after three months, the median was 32mg/dl, and after six months, it was 30 mg/dl.

Table 2 Measurement of Urea for Cases and Controls at Zero Time, After 3 Months and 6 Months

Urea	cases	p-value	Controls	St. Dev.cases	St.dev controls	p-value
Zero time	29		26	7.6874	11.0005	
3 months	30	0.548	30	8.4797	7.6923	0.212
6 months	31		32	8.908	9.306	

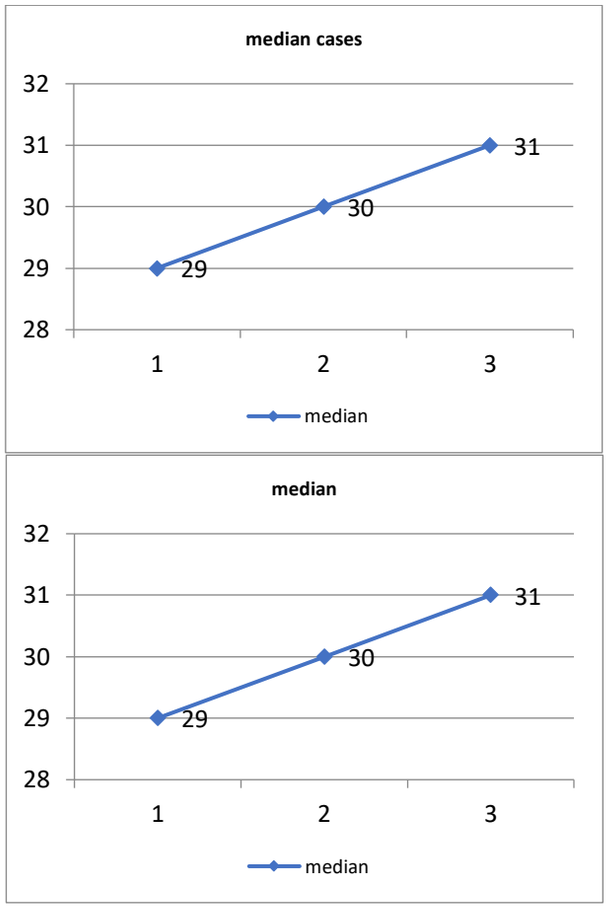


Figure 2 Median of Urea of Cases and Controls vs Time

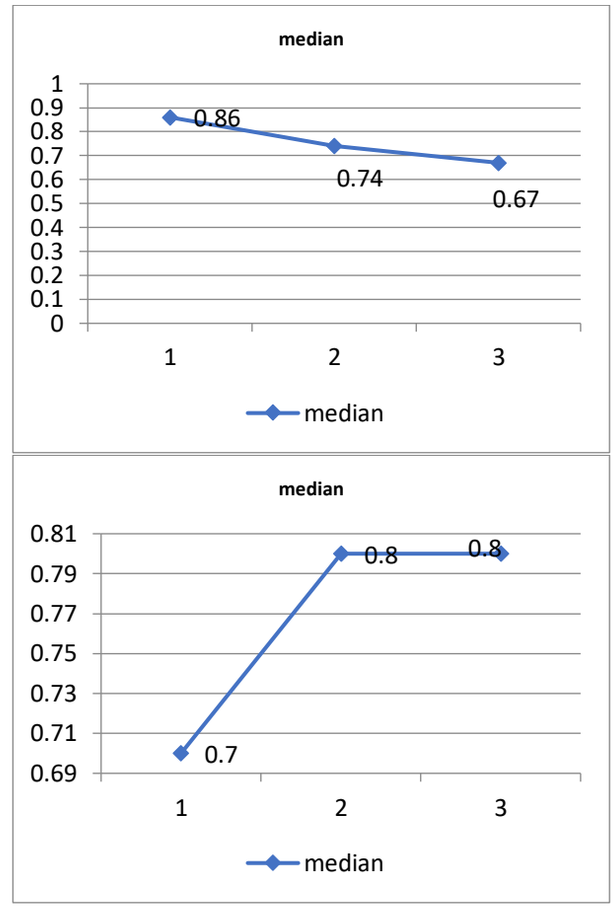


Figure 3 Median of Creatinine of Cases and Controls vs Time

Creatinine for Cases

Creatinine for cases was measured at zero, after three months, and after six months. The median at zero time was 0.86 mg/dl; after three months, the creatinine was not significantly declined with P-value at 1; and after six months, the median of creatine declined significantly to 0.67 mg/dl with P-value at 0.03.

Creatinine for controls was measured at zero, after three months and after six months. The median was 0.77 mg/dl at zero time; after three months, 0.8, and 0.8 after six months.

Table 3 Measurement of Creatinine in Cases and Controls at Zero Time, After Three Months and Six Months

Creatinine	cases	p-value	Controls	St. Dev.cases	St.dev controls	p-value
Zero time	0.86		0.77	0.15898	0.16164	
3 months	0.74	0.03	0.8	0.29014	0.14192	0.525
6 months	0.67		0.8	0.10487	0.12182	

–

Total Cholesterol TC for Cases

The total cholesterol was measured for cases at zero time, after three months, and after six months. The median of cholesterol was significantly elevated after six months, with P-value at 0.003.

Total Cholesterol for Controls

Total cholesterol for controls was measured at zero time, after three months, and six months. The median at zero time was 177 mg/dl; after three months, it elevated significantly to 204 mg /dl.

Low-Density Lipoprotein (LDL) for Cases

It was measured at zero time, after three months, and six months. The median was 118 mg/dl; after three months, it elevated 119 mg /dl, and after six months, it elevated non significantly to 133mg /dl

Low-Density Lipoprotein (LDL) for Controls

For controls, the median at zero time was 120 mg/dl; after three months, it was 118 mg/dl,

and after six months, it was 128 mg /dl (not significant).

High-Density Lipoprotein (HDL) for Controls

For controls also, there were no significant changes on HDL at zero time, after three months and six months with a P-value of 0.78.

Table 4 Measurement of TC for Cases and Controls at Zero Time, After 3 Months and 6 Months

	Cases						Controls				
	TC.	St dev	LDL	St dev	HDL	St dev	TC	St dev	LDL	St dev	HDL
Zero time	177	23.850	118	16.28	38	8.97	107	42.02	120	35.6	54
3 months	210	49.585	119	40.2	44	15,3	204	59.25	118	45.3	49
6 months	203	51.498	133	39.7	47	12.48	222	58.23	128	50.88	55
p-value	0.003		0.191		0.266		0.00		0.267		0.78

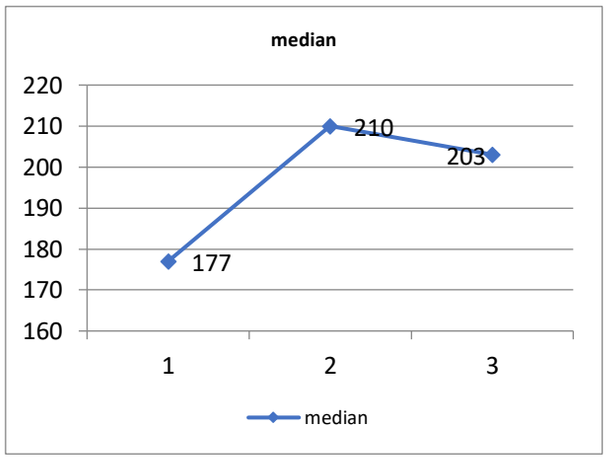


Figure 4 Median of Total Cholesterol of Cases vs. Time

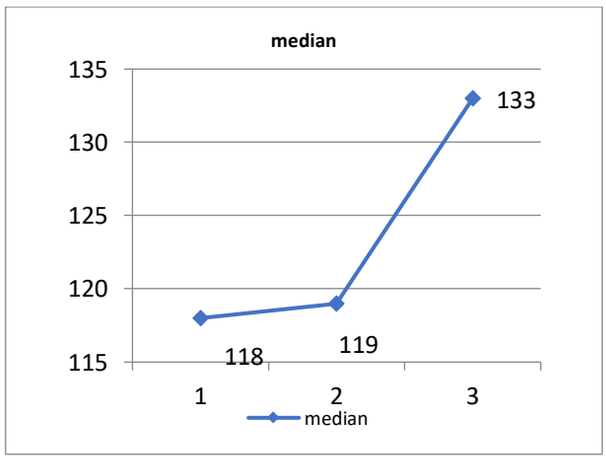


Figure 5 Median of LDL for Cases vs. Time

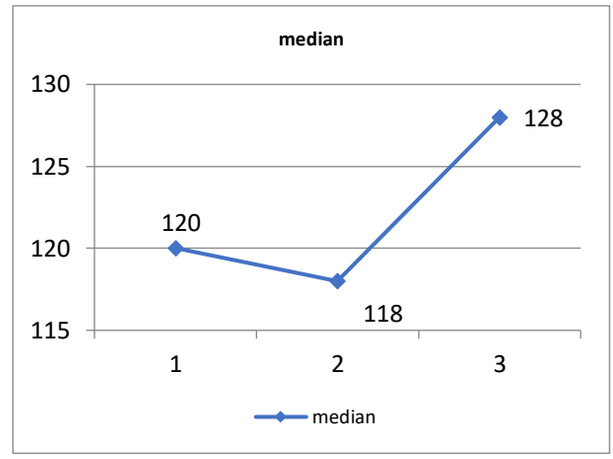


Figure 6 Median of LDL of Controls vs. Time

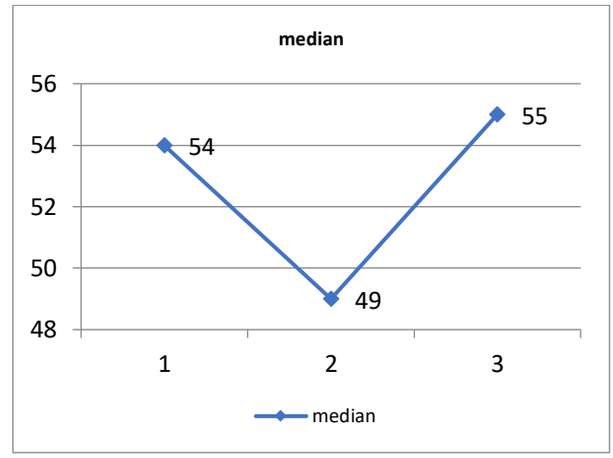


Figure 7 Median of HDL of Controls vs. Time

Measurement of Vomiting Pre and Post Treatment with Alpha-lipoic Acid

The mean of the number of vomiting before treatment with ALA was 5.5 times per day; 10 out of 15 cases had no longer vomiting problems, while 5 were still not affected with P-value at 0.005.

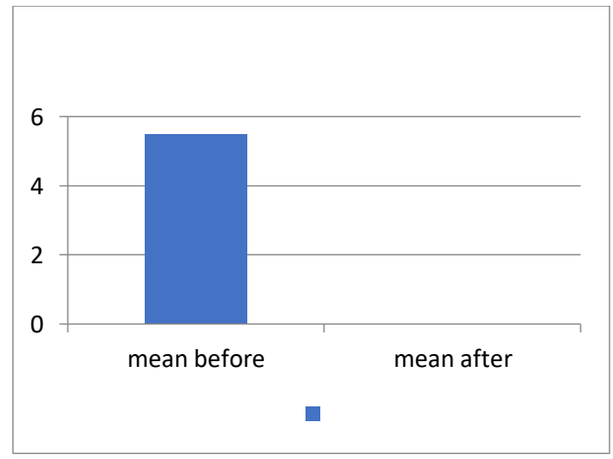


Figure 8 Diagram Demonstrating the Mean of CINV Before and After ALA

Table 5 Demonstrating the Percentage of Cases that Are no Longer Complaining of CIPN

	pain	burning	tingling	Trouble in holding things	numbness	balance
Decrease in Percentage of cases complaining After ALA	58 %	69%	83%	81%	80%	33%
Significance level	0.07	0.004	0.002	0.004	0.008	0.125

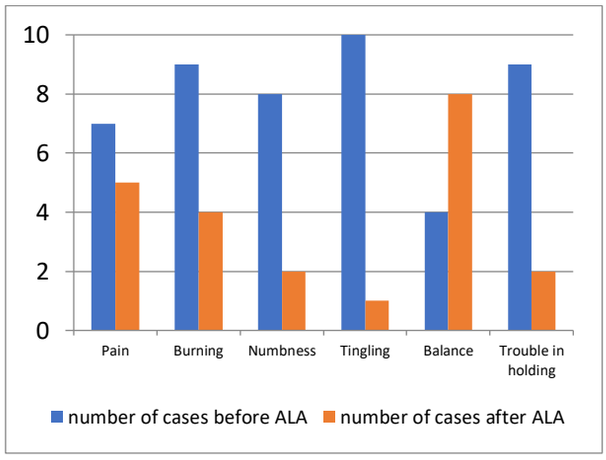


Figure 9 Diagram of Number of Cases Complaining of CIPN Before and After Treatment with Alpha-Lipoic Acid

DISCUSSION

Breast cancer is one of the global public health problems. It is the third most common cancer leading to the death of women worldwide ***(Tupurani et al.,2013).***

Extensive research during the last two decades revealed the mechanism by which continued oxidative stress can lead to chronic inflammation and mediate most chronic diseases, including cancer ***(Reuter et al., 2010).***

In cancer treatment, there is a consequent reduction of the antioxidant defense system. Also, a direct attack of ROS produced during chemotherapy treatment causes oxidative damage in cellular structures ***(Rossi et al.,2009).***

Serum Measured Parameters:

Malondialdehyde (MDA) is a widely used oxidative stress biomarker. It is used to measure the oxidative stress in a cancer patient because it tells us how much carcinogenesis are there in those patients. It was used in different types of cancers as a biomarker for oxidative stress ***(Sharif et al.,2009).***

Alpha-lipoic acid is an antioxidant widely investigated in recent studies in cancer therapy because of its beneficial effect on tumor cells and peripheral neuropathy. Some studies used MDA as an indicator of the effect of alpha-lipoic acid.

Several areas of investigation have implicated that MDA levels in breast cancer women are elevated because of high oxidative stress ***(Gonec et al.,2001).***

Junior et al. examined the MDA in breast cancer women. His study aimed to evaluate the oxidative parameters of erythrocytes and genotoxicity in leukocytes of patients with breast cancer. His study involved a total of 56 individuals, including 28 patients exposed to chemotherapy by the AC protocol (Adriamycin 60 mg/m2and cyclophosphamide 600 mg/m 2) and 28 patients not exposed to chemotherapy. Results showed that the oxidative was increased, represented by MDA elevation compared to controls ***(Junior et al.,2015).***

The value of MDA was also used by Diazapetrin et al. as an indicator for patient survival. He used Kaplan- Meier survival estimates for this purpose in which he divided the values of MDA to $\leq$ 8.6 and those are $\geq$ 8.6 ***(Diazapetrin et al.,2014).***

Sharif et al. (2009) examined the level of MDA in different types of malignancies and found that the value of MDA increased with advanced stages.

In this study, MDA value has not been affected by breast cancer, and so the value of MDA has not related to stage.

Similar to my findings, Zarini et al. (2016) examined oxidant/antioxidant status in breast cancer patients in different stages. He analyzed MDA in different stages and concluded that the severity of oxidative stress in different stages is similar to some extent.

Shariff et al. (2009) also examined the effect of the use of antioxidants. The pretreatment means serum MDA levels of head and neck malignancy patients showed a marked and significant increase. The pretreatment mean serum MDA levels of head and neck malignancy patients showed a marked and significant increase. The post-treated mean serum MDA of Group I (those with lower MDA values) showed a statistically significant lower value.

The study results agreed with these studies, as the median of MDA was significantly decreased after three months of antioxidant (alpha-lipoic acid) from 8.4 to 4.6), with a P-value of 0.013. The median of MDA after 6 months was also not significantly decreased, but it mostly became close to the normal level of MDA(2-4) mmol/l in healthy individuals, while the median of control remained 7.1.

These findings stressed the idea that the MDA value as an indicator of lipid peroxidation. Some studies indicated that MDA would be raised during chemotherapy, but MDA's value was not affected during chemotherapy in the control group in my study.

In some cases, alpha-lipoic acid decreased the median of MDA, so expecting a decrease in carcinogenesis and a better prognosis with cancer therapy.

Cupta et al. examined the oxidative stress in breast cancer patients and lipid profile. The study stated that Reactive oxygen species (ROS) such as hydrogen peroxide, superoxide anions, and hydroxyl radicals are capable of abstracting a hydrogen atom from polyunsaturated fatty acids in membrane lipids to initiate lipid peroxidation.; a significant increase in total cholesterol and LDL in breast cancer patients compared to control group ***(Cupta et al.,2012).***

Data of present investigation revealed a significant increase in the level of cholesterol levels.

Complications of the Use of Chemotherapy

The involvement of reactive oxygen species (ROS) produced during chemotherapy has damaging effects on the mitochondria of the kidney. So the renal function is well documented in cancer patients. Malarkodi implicated that the use of alpha-lipoic acid in adriamycin-induced peroxidative damages in rat kidneys. The study has highlighted the beneficial effects of lipoic acid pretreatment in reversing the damages caused by adriamycin ***(Malarkodi et al.,2003).***

In this study, creatinine and urea were examined to investigate the protective effect of alpha-lipoic acid; significant decrease in creatinine level was observed. The first three months revealed no significant effect of alpha-lipoic acid on kidney function, but in the second three months, it was significant, with P value at 0.03, which means it is important to give alpha-lipoic acid for six months. However, there were no effects on urea.

Cisplatin-induced decreases in renal function, measured by blood urea nitrogen, serum creatinine level, and renal tubular injury scores, were attenuated by α-LA treatment ***(Kang et al.,2009).***

In breast cancer women, the lipid profile is affected during chemotherapy by ROS's effect, so we observed that breast cancer women have a significant increase in total cholesterol, LDL, and decrease in HDL. Cupta et al. examined total cholesterol, LDL, and HDL in breast cancer women and found a significant increase in LDL and TC mean but not HDL. This agreed with my study, which revealed that cholesterol was significantly raised in all breast cancer patients in both cases and controls.

The present study shows no effect of using ALA on lipid profile as expected. The total cholesterol was significantly elevated so was the LDL. There was no significant amelioration on HDL level; this result highlights questions related to the correlation between lipid profile and lifestyle in Gaza Strip in which dyslipidemia is highly prevalent.

In contrast to my study, Zulkhairi et al. investigated the effect of alpha-lipoic acid on lipid profile. The analysis revealed that the level of TC was significantly reduced in most of the treatment groups compared to control.

Symptoms of CIPN

Several prospective experimental studies in animal models suggested that mitochondrial dysfunction is associated with chemotherapy and axonal mitotoxicity contributes to neuropathic symptoms produced by various chemotherapeutic agents. Identification of these mechanisms might help identify newer biomarkers for the CIPN and thus increase the chances of getting improved therapeutic strategies ***(Areti et al.,2014).***

The symptoms of chemotherapeutic-induced peripheral neuropathy (CIPN) were mostly seen during taxol therapy. These symptoms were; pain,

burning, tingling sensation, imbalance, and trouble holding or picking with hands.

All these symptoms were examined through a direct questionnaire to the cases before and after using the alpha-lipoic acid. The number of patients suffering from pain and imbalance was not significantly decreased, while other symptoms were significantly decreased. The study showed significant palliation to symptoms of CIPN.

Pain was not significant; the percentage of cases complaining of pain after treatment with alpha-lipoic acid was 58%. The P-value was> 0.05. It might be significant if the sample was larger.

The imbalance was not significant even if the sample was larger. Patients would still be complaining from imbalance, so there was no effect of alpha-lipoic acid on the balance of the patient, where p- value was > 0.05.

Numbness was highly significant with P-value <0.05; 80% of patients have no numbness after six months of alpha-lipoic acid treatment.

Tingling sensation is a very upsetting symptom for patients receiving chemotherapy. The results revealed a significant decrease in the percentage of patients after treatment with alpha-lipoic acid, which was 83% with P-value < 0.05.

Patients also usually complain of trouble picking things from the floor or even holding things with their hands. This symptom was significantly decreased with P-value of < 0.05. 81% of cases were no longer suffering from trouble holding or picking things.

In agreement with my study, Melli et al. examined the neuroprotection effect of alpha-lipoic acid in vitro using taxol, which exerts neurotoxicity through hyper stabilizing microtubules cross-linking and consequently altering axonal transport and growth ***(melli et al. 2008).***

Neuroprotection effect of alpha-lipoic acid through investigation of MDA of spinal cord tissue, in which the content of MDA was examined by Toklu et al. The content of MDA in the spinal cord was significantly elevated in control rats indicating the presence of enhanced lipid peroxidation in the treatment of alpha-lipoic acid, which completely prevented the elevation of MDA ***(Toklu et al., 2010).***

The results of these studies which agree with my study results give a potentially promising area of neuroprotective drug discovery for CIPN.

Areti et al. reviewed the CIPN during chemotherapy due to high oxidative stress and suggested MDA as an indicator of oxidative stress biomarker due to high oxidative stress induced by a chemotherapeutic agent. He suggested MDA as an indicator of oxidative stress ***(Areti et al.,2012).***

Vomiting is a significant problem in the treatment with chemotherapy. This study examined the effect of alpha-lipoic acid on vomiting by asking patients directly about the number of vomiting before and after treatment with alpha-lipoic acid. It showed a decrease in the number of vomiting per day after treatment with a P value> 0.05. Similar to my study, the findings of Mantovani et al. examined the effect of antioxidants on the side effects of chemotherapy as fatigue, nausea, and vomiting. All patients were given as basic treatment polyphenols plus antioxidant agents α-lipoic acid, carbocysteine, and vitamins A, C, and E, all orally. After 2 years, no severe side effects, like nausea and vomiting, were observed ***(Mantovani et al.,2008).***

CONCLUSION

The results concluded the beneficial effect of alpha-lipoic acid as an antioxidant in breast cancer patients. This was obvious from the number of factors that significantly affected the patient.

There is an elevated level of MDA, the biomarker of lipid peroxide, in breast cancer patients compared to the normal healthy individual, supporting the idea that cancer patients have an imbalance between oxidant/antioxidant and so high oxidative stress.

The oxidative stress plays a great role in the pathogenesis of cancer and will also increase the chance of metastasis to other organs.

Chemotherapeutic agent induces ROS increasing the oxidative stress during therapy. This ROS will not only affect the cancer cells; on the contrary, it will affect the normal cells inducing the side effects reported from chemotherapy and will affect the QOL of the patient.

Treatment with alpha-lipoic acid significantly decreases the median of MDA by 3.8 nmol/ml and attain it to about the normal range. This leads to a decrease in oxidative stress in breast cancer patients and a decrease in carcinogenesis. It

will also restrict the ability of metastasis which is the major problem with cancer patient. Although the significance was in the first three months, giving alpha-lipoic acid for six months can attain the MDA to about the normal level or restrict the elevation resulting from chemotherapy. We cannot forget that the patient compliance effect must be taken into consideration and may affect the results.

Alpha-lipoic acid has a beneficial effect on creatinine, so protecting the effect on kidney function as expected from antioxidants when used concomitantly with chemotherapy. Breast cancer protocol in Gaza Strip includes Adriamycin which has a harmful effect on renal function. The significance was observed in the second three months, which means that if we want the protective effect of alpha-lipoic acid on the renal function, we have to give alpha-lipoic acid for six months.

Symptoms of CIPN disturbed patients and affected their QOL. Patients are weak, feeling severe pain, unable to do anything by themselves, unable to eat or sleep because of the neuropathy.

Alpha-lipoic acid has a neuroprotective effect. Only in pain and imbalance alpha-lipoic acid has no significant effect on the number of cases complaining. Other symptoms (burning sensation, tingling sensation, numbness, and trouble holding and picking things) are all significantly ameliorated using alpha-lipoic acid. Thus, giving alpha-lipoic acid for six months has a beneficial effect for chemotherapy-induced peripheral neuropathy and helps patients overcome the harmful period (the course of chemotherapy) and contribute to improving quality of life for these patients, especially breast cancer patients who are women and are mothers of children and play important roles in the community.

There was no effect of alpha-lipoic acid on the lipid profile of breast cancer patients who usually have elevated levels of total cholesterol, LDL, HDL, and no beneficial effect from using alpha-lipoic acid for hypercholesteremia.

Chemotherapeutic-induced nausea and vomiting restrict the patient's ability to eat and lead to weakness and severe gastric pain. ALA helped patients to overcome this problem and decrease their complaints of nausea and vomiting. Patients complaining of vomiting during chemotherapy can take it as an adjuvant to other antiemetic drugs.

All effects of ALA come from its potent antioxidant effect, which is represented by its great role as a neuroprotective, antiemetic, and preventive effect of metastasis.

RECOMMENDATIONS

We recommend that the Ministry of Health add alpha-lipoic acid to the breast cancer patient's regimen to mimic the cytotoxic effects of chemotherapy and ameliorate the side effects of chemotherapy.

Physicians should be aware of the importance of antioxidants in the nutrient of breast cancer patients and the supplement of synthetic antioxidants especially ALA, the regenerator of other antioxidants.

Further studies have to be done in this field to see the feedback of decreasing the MDA in cancer patients and how it will be reflected on the prognosis of the disease.

More attention should be given to the scientific research in cancer therapy in Gaza Strip. IV of ALA can be more effective than oral, and so we recommend prescribing IV product.

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A Prediction Model of Newly Admitted Students in the Level Exam Using Data Mining

توقع لأداء الطلاب المقبولين الجدد في امتحان المستوى باستخدام التنقيب في البيانات

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ABSTRACT

In this research, we will use the Data Mining technique as a prediction model to predict the student's grade in the level exam. At the same time, we are interested in finding the main factors that affect the grade. In order to analyze and predict what will happen during the various stages of the enrollment process at the University, data mining models will be used. This will help the university determine the interventions and measures needed and take the required action accordingly at the right time. To perform the analytics and the predictions, we used Waikato's Knowledge Analysis Environment (WEKA) tool and different algorithms such as K-Means, logistic regression, Kohonen's Self Organizing Map (KSOM), as well as EM to identify the most influential factors that predict student's grade in the level exam. The results of this research showed that EM offers great value to determine the main parameters that affect the student's final grade in the level exam. The other three algorithms, logistic regression, K-Means, and KSOM are advanced predictive models for the student's grade in the level exam.

Keywords: Data Mining, logistic regression, neural networks, level exam grade, K-means, EM Algorithm, Kohonen's Self-Organizing Map (KSOM) and Clustering.

الملخص

هذا البحث، سنستخدم تقنية التنقيب في البيانات كنموذج تنبؤ لتوقع علامة الطالب في اختبار المستوى. في الوقت نفسه، نحن مهتمون بإيجاد العوامل الرئيسة التي تؤثر على هذه العلامة أو النتيجة. من أجل التحليل والتنبؤ بما سيحدث خلال المراحل المختلفة لعملية التسجيل في الجامعة، يمكن استخدام نماذج التنقيب عن البيانات التي ستساعد الجامعة في تحديد التدخلات، والتدابير، واتخاذ الإجراءات اللازمة، وفقًا لذلك في الوقت المناسب. لإجراء التحليلات والتنبؤات، استخدمنا أداة Waikato's Knowledge Analysis Environment (WEKA) وخوارزميات مثل(K-Means)، والانحدار (اللوجستي)، وخريطة (Kohonen) ذاتية التنظيم (KSOM) و(EM) لتحديد العوامل الأكثر تأثيرًا على تنبؤ علامة للطالب في اختبار المستوى. أظهرت نتائج هذا البحث أن (EM) تظهر أداء جيد لتحديد العوامل الرئيسة التي تؤثر على العلامة النهائية للطالب في اختبار المستوى. تعد خوارزميات الثلاثة الأخرى المستخدمة الانحدار (اللوجستي، K-Means، KSOM) نموذجًا تنبئيا لعلامة الطالب في امتحان المستوى.

الكلمات المفتاحية: تنقيب في البيانات، الانحدار اللوجستي، الشبكات العصبية، علامة امتحان المستوى،K-means ، EM خوارزمية، خريطة كوهن ذاتية التنظيم (KSOM) والتكتل.

INTRODUCTION

The amount of structured and unstructured educational data is increasing rapidly in the last decade. The data hides valuable information about students like major, high school background, admission type, grade point average (GPA), attendance, assignments, quizzes, lab work, tests, final exams, and extracurricular activities. Furthermore, social interaction networks, psychometric factors, and students' demographics like address, age, gender, and family background are very interesting and are very interesting and manageably assessed.

Educational data mining is an emerging discipline that is used to extract information from educational data, which is important for various stakeholders like students, academic advisors, teachers, administration, and educational systems.

Nowadays, many data and information related to academic and education field are available on academic portals, online repositories, and research centers. Researchers can use this information and apply different data analyses to obtain important information to support different educational system stakeholders. They can use data mining techniques in many areas in education and university admission.

This study focuses on identifying the main parameters that affect the prediction of the student's grade in the level exam using data mining. Different algorithms are used to assist in predicting and deciding the main parameters that affect the analysis and prediction.

In this study, we obtained the data from one of the educational branches of al-Quds Open University and the Ministry of Education in Palestine. Different algorithms have been used to analyze the data like K-Means, logistic regression, Kohonen's Self Organizing Map (KSOM), and EM on the dataset. According to the analysis of the data and the results, the most accurate results are achieved by EM to predict the key parameters that affect the prediction of the student's grade in the

level exam. While logistic regression, K-Means, and KSOM could be used as effective tools in predicting concrete compressive strength.

The remainder of this paper is organized as follows. In Section 2, we review existing literature of the researches in data mining in education. An overview of data mining techniques and WEKA is presented in section 3. Section 4; describes our approach, framework model, and methods used in this study, followed by a discussion regarding the findings from this research in Section 5, and a summary and conclusions in Section 6.

LITERATURE REVIEW

The main idea of data mining predictive models is to use historical data to predict the new and future values of an outcome based on one or more input parameters. Data mining has been used to assist decision making in different fields, including healthcare (Abuzir Y. et al. 2020), civil engineering (Abuzir Y and Abuzir S. 2020), the stock market (Abuzir Y. et al., 2019), Agriculture (Abuzir, 2017), manufacturing, service, and academia. Several studies have discussed the development of data mining techniques for decision-making in higher education.

Ahmed and Elaraby (2014) applied educational data mining to predict the student's performance using the decision tree (ID3) classification method. The data set consisted of 1548 records obtained from an educational institution in the years 2005-2010 from the Information System Department. The study could identify students who needed special attention to reduce the failing ratio and take the required action accordingly at the right time.

Mohammad M. Abu Tair and Alaa M. El-Halees (2012) used educational data mining to discover knowledge. The collected data covered fifteen years from the College of Science and Technology in the Islamic University of Gaza in Khan Younis. The authors used two classification methods to predict the grade of graduate students. In addition, they discovered association, clustering, and outlier detection rules where they described the extracted knowledge for each of them. The study could predict low grades on time and, consequently, helps college management predict those students from the beginning and enhance their performance before graduation.

Brijesh Kumar Baradwaj and Saurbh Pal (2011) conducted a study on student performance based on information like attendance, seminar, assignment, and class test. The study was performed on a data set of 50 students from VBS Purvanchal University, Jaunpaur (Uttah Pradesh) Computer Applications Department of Master of Computer Applications course (MCA) in the years 2007-2010. The study could help identify the students who needed special attention to reduce the failing ratio and take the needed action for the next semester's examination.

Sonali Agarwal, G.N. Pandey, and M. D. Tiwari (2012) conducted a comparative analysis on community college student database among various classification approaches. Support Vector Machine was established as the best classifier with minimum root mean square error (RMSE) and maximum accuracy. The Radial Basis Kernel was identified as the best choice for the Support Vector Machine. The study showed the importance of data availability and the use of different parameters to evaluate students' admission academic performance and, finally, the placement test.

Alaa El-Halees (2009) used educational data mining to analyze students' behavior in a database course. The author preprocessed the data then applied various data mining approaches to discover classification, association, clustering, and outlier detection rules. He extracted knowledge from each of them that describes students' behavior. The study showed how useful data mining could be to improve students' performance.

Wati et al. (2017) , compares the efficiency of data mining techniques using Naïve Bayes Classifier and Tree C4.5 algorithms. Algorithms are used to predict student-learning outcomes. The result shows lower average accuracy for Naïve Bayes Classifier and Tree C4.5

Shahiri et al. (2015), Algarni, (2016), Dahiya V. (2018), Purani et al. (2019) and AlHakami (2020) presented a survey on various components of educational data mining along with its objectives. The main objectives of these researches are to present different data mining techniques used in education. They also strive to compare and evaluate the performance of the different data mining techniques in predicting, advising, dropout, and analysis of students' learning environment. They also want to provide

appropriate recommendations and meet the main goals of data mining for education.

Data mining in the educational systems is one of the most recent research topics. In the field of education, many research applied different approaches to data mining and Artificial Neural Network technologies. Data mining techniques are applied for education in multiple case studies (Villanueva, 2018). Table 1 summarizes different data mining techniques widely applied in different domains linked to education and its objectives.

Table 1 Classification of Data Mining Researches in the Domains of Education

Domain	Description	DM Techniques	References
Dropping out or Retention Analysis	Analysis of factors related to dropout and student retention.	Decision Trees, Classification, Neural Networks.	(Bayer et al., 2012), (Thomas, 2015), (Yukselturk &Education, 2014).
VLO or VLE Analysis	Analysis of VLO virtual learning objects or Virtual Learning Environment (VLE).	Correlation Analysis, Regression Trees, Classification, Clustering, Sequential Patterns, Bayesian Networks, Neural Networks, Association rules, Linear regression.	(Ali Yahya et al., 2013), (He, 2013), (Rabbany et al., 2014), (Dutt et al., 2015).
Performance and students evaluation Analysis.	Analysis of the performance of students or their assessment during face-to-face or virtual courses.	Decision Trees, Regression Trees, Classification, Clustering, Sequential Patterns, Bayesian Networks, Neural Networks, Association rules.	(Badr et al., 2014), (Hu et al., 2014), (Shahiri & Husain, 2015).
Generation of Educational Recommendations.	Generate recommendations for the educational process.	Decision Trees, Markov Chains Clustering, Sequential Patterns, Association rules.	(Hung et al., 2012), (Chalaris et al., 2014).
Learning pattern Identification	Analysis of the ways in which virtual students develop in the learning environment and try to establish the way in which they learn.	Decision Trees, Classification, Clustering, Sequential Patterns, Bayesian Networks, Neural Networks, Association rules, Linear regression.	(Chalaris et al., 2014), (Belsis et al., 2014), (Mayilvaganan & Kalpanadevi, 2015).
Students patterns Identification	Data analysis of educational environments, which identified patterns among students.	Correlation Analysis, Decision Trees, Classification, Clustering, Differential Sequence Mining, Sequential Patterns, Bayesian Networks, Association rules.	(Mugla, 2014), (Campagni et al., 2015).
Students related Prediction:	Predictions relating to students, predictions in the final grades, performance, behavior in specific courses, etc.	Decision Trees, Classification, Clustering, Sequential Patterns, Bayesian Networks, Neural Networks, Association rules, Linear regression.	(Barracosa & Antunes, 2011), (López et al., 2012), (Oladokun et al., 2008), (Şen et al., 2012), (Kaur et al., 2015), (Trivedi et al., 2016).

The study of Mengash (2020) focuses on ways to support universities in admissions decision-making using data mining techniques to predict applicants' academic performance at the university. The results demonstrate that applicants' early university performance can be predicted before admission based on certain pre-admission criteria (high school grade average, Scholastic Achievement Admission Test score, and General Aptitude Test score). The study used the Artificial Neural Network technique with an accuracy rate above 79%.

The work of Sani and Babandi (2020) aims to analyze and evaluate student performance in the Department of Computer Science, Jigawa State Polytechnic. A decision tree model is applied during the experiment. The results indicate that it is possible to predict graduation performance; in addition, a procedure for evaluating the performance for each course has been identified.

The work of Mayreen A. & Alexander H. (2019) presents the outcomes of linking an educational data mining approach to the model of students' academic performance. Three data mining classification models (Naïve Bayes, Decision Tree, and Deep Learning in Neural Network) were defined to analyze the data set and predict students' performance. Results show that the Deep Learning classifier beats the other two classifiers by gaining an overall forecast accuracy of 95%. Their analysis and information about prediction help college administration and faculty members improve education and make changes if necessary.

The paper of Patel (2020) presents a literature research on data mining methods used to predict student's performance from 2002 to 2020. This paper reviews work done by different researchers to predict student's performance from all perspectives. The paper also discusses commonly used attributes in different research for the student performance analysis.

The study of Alyahyan and Düştegör (2020), aims to provide a step-by-step set of guidelines for educators willing to apply data mining techniques to predict student success. This study provided

educators with an easier access to data mining techniques, enabling all the potential of their application to the field of education.

AN OVERVIEW OF DATA MINING AND WEKA

Data mining is a process or a technique of applying different algorithms on a huge dataset for extracting beneficial information or knowledge. Its intelligent tools are required to apply data mining techniques to manipulate datasets.

Data mining is often used as a combination of intelligent and non-traditional sciences like business analytics, mathematics, logic, statistics, artificial intelligence, machine learning, and artificial neural networks Dweib and Abuzir (2018) and Abuzir and Baraka (2019). In data mining, researchers can use different algorithms in the analysis of the data. These algorithms can be used for Classification, Clustering, Prediction, Decision Trees, Association, and Sequential Patterns (Brown, 2012).

There are different steps in data mining as follows (as shown in Figure 1):

- Data Selection,
- Preprocessing - Data Cleaning,
- Data Transformation,
- Data Mining - Pattern Evaluation and Knowledge Presentation
- Evaluation - Decisions/Use of Discovered Knowledge

There are different useful tools of Educational Data Mining:

- WEKA (Waikato Environment for Knowledge Analysis)
- KEEL (Knowledge Extraction Based on Evolutionary Learning)
- RapidMiner
- R language
- KNIME (Konstanz Information Miner)
- ORANGE

WEKA is an abbreviation for Waikato's Knowledge Analysis Environment. It is an open-source tool developed at the University of Waikato in New Zealand. WEKA is a Java-based tool that involves many open-source data mining and machine learning algorithms. WEKA has the following features (Abuzir Y and Abuzir S., 2020):

- Data processing tools.
- Classification, clustering algorithms and relationship mining (association rules, correlation and sequential patterns).
- User graphical interface.
- WEKA data mining and Machine learning tools

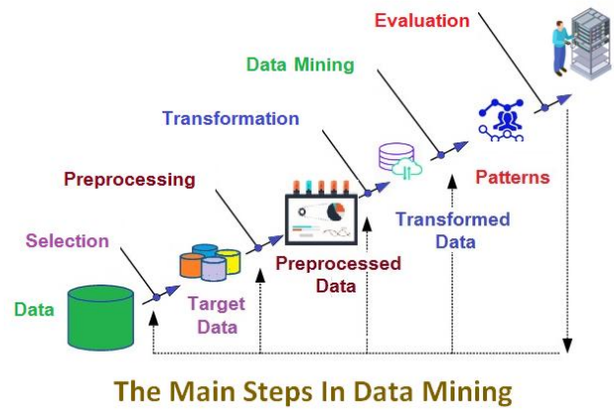


Figure 1 The Main Steps in Data Mining

MATERIALS AND METHODS

A brief overview of different data mining algorithms is needed to predict the output of students. This section will discuss the basis of data mining algorithms with their performance on our case study and the effect of the students' different attributes on the prediction model. Figure 2 illustrates the process of prediction model flow.

Huge volumes of data are now stored in educational information systems, and it comes from various sources, different formats, and different granularity levels. The problems of educational data mining must be explored and analyzed carefully. This will help us achieve the basic goals of data mining in education.

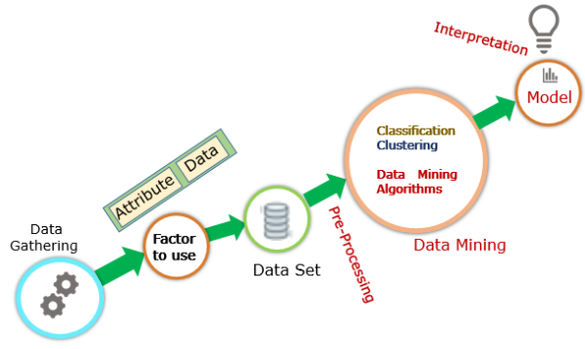


Figure 2 Process for Predication Model

This paper investigates different data mining techniques and algorithms that can be adequately utilized to note the issues of predictions of students' performance in the level exam and predict the main factors that affect the level exam results. WEKA workbench as a data mining tool has many tools, algorithms, and graphics techniques that can be used in our study to predict the performance of newly admitted students in the level exam. Most of the algorithms are built in this tool. The features of the datasets and algorithms employed in this analysis are addressed in the following paragraphs and subsections. It addresses in depth the methodological approach used to establish the prediction model of the key factors affecting the prediction of the level exam performance for the newly admitted students.

Datasets

This research aims to use data mining techniques to predict the student's performance in the level exam. It helps the admission officers at the University decide how to allocate different university recourses for the newly admitted students. The idea behind this use is to help enhance the quality of managing student admission.

As a first step, we collect the data. The data used for this purpose were collected from the Admissions Office in a local branch of al-Quds Open University. As input to the prediction model, 17 variables are selected. We collected two types of data: Personal Attributes and Academic Attributes. The selection of attributes is based on their capacity to provide appropriate predictability. The collected data relates to the following personal attributes of students: Tawjihi seat number, student ID number, intended majors, academic plans (joined academic term), gender, job position, marital status, and residency. In addition to that, data regarding the students' grades in the following level exams, Arabic, English, and Computer, were collected. Other data were collected from the Ministry of Higher Education, which contained grades from the Tawjihi General Exam, such as Arabic Language, English Language, and Computer. As an Output variable for our model, we selected students' grades for the level exam. However, data regarding the students' financial issues and financial aid was not collected, due to privacy concerns. After eliminating incomplete data, the sample comprised 5621 student records.

In the second step, we removed some of the parameters and preprocessed the data. Later, we analyzed these data using the WEKA tool to identify any existing patterns and develop predictive analytics models. Using this model, we predict the main parameters that affect the prediction of the grade for level exams and estimate the level exams' grade for the newly admitted students. This model can be adopted and customized by institutions to predict the grade for the different level exams.

We obtained the statistical analysis using WEKA to complete Table 2. WEKA supports users with two ways to split data:

- The first method is training and supplied test set
- the second method is a percentage split

These groups are not included in each other during the training phase. To do the statistical analysis of the datasets, we divided the datasets (5621 records) into two groups: Training set (3710 students records) 66% and testing set (1911 students records) 34%. After splitting the data into training and testing data, the statistical analysis and data mining algorithms are accomplished to present the results.

Table 2 Numeric Datasets for Student Ranges (WEKA)

Name of Parametert	Maximum	Minimum)	Mean	SDV
CUM_AVG	87.62	0	64.282	13.247
Tarabic	90	0	50.579	11.724
Tenlish	100	0	44.212	13.261
Tcomputer	97	0	49.118	10.843
UArabic1	90	0	50.782	5.11.547
UEnglish	100	0	44.08	13.539
UComputer	97	0	49.611	10.94

DATA MINING ALGORITHMS

Data mining techniques are used to create a model according to which hidden data can discover new knowledge. The essential tasks of data mining techniques are predictions based on the automatic discovery of new relationships and attribute dependencies in the data observed.

There are many different machine-learning algorithms used in data mining models. In this study, we test four different Machine Learning (ML) algorithms to find the main parameters that affect the student's grade of the level exam and predict the grade level exam. The following paragraphs show a brief description of these ML algorithms.

Logistic Regression: It is a statistical tool used for estimation and prediction by using the logic function.

EM (Expectation Maximization) is a clustering algorithm used in data mining. It is based on two iterative steps. The first one is the centroid, where each object is assigned to the most likely cluster. In the second step, we recomputed (Least Squares Optimization) for the centroid.

Another algorithm is the Kohenon Self Organizing Map (KSOM), also called vector quantization. KSOM is an artificial neural network used in unsupervised learning and is considered one of the most known clustering algorithms.

Simple K-Means Clustering is used as an unsupervised learning algorithm and uses Euclidean distance measure to compute distances between instances and clusters.

Given the data <x1, x2,…,xn> and K, assign each xi to one K clusters, C1…Ck, the following algorithm is used to apply K-Means:

1-Set $\mu_1 \ldots \mu_k$ randomly
2-Repeat the following steps until convergence:
2.1-Assign each point xi to the cluster with closest mean μ_j
2.2- Calculate the new mean for each cluster (equation 1)

$$\mu j = \frac{1}{|C_j|} \sum_{x_i \in C_j} x_i \quad \ldots\ldots(1)$$

In our study, we used the four following data mining techniques: Logistic Regression, EM, KSOM, and K-means algorithms to analyze data regarding the student's grade in the level exam. This type of analysis will then be used to help in decision making at the University and make a plan to facilitate other general decision-making regarding the allocation of staff load and other facilities and administration issues.

We utilized these different data mining algorithms with different configurations to identify useful data patterns and errors and predict approximate and effective results.

We analyzed and evaluated the results. The results will guide us towards identifying the ideal profile of parameters that minimizes scores of the different parameters like Standard Deviation (SD) and Root Mean Squared Error (RMSE).

RESULTS AND DISCUSSION

In this study research, we used the Data Mining Tool WEKA. It is one of the most professional and extensive packages for machine learning algorithms.

In order to understand the importance of the input variables in our model, it is very important to analyze the impact of input variables on the output variable during the prediction using the ML algorithms. The used algorithms provide very different results based on the relevance of features in a different way. Some features are not applicable to determine the output. The following seven features were removed in the analysis of our dataset: TWA_SEAT, BRANCH_NAME, STUD_ID, JOIN_TERM_NO, JOB_A_NAME, and MARITAL_STATUS.

In this section, we utilized data mining techniques in predicting and finding the main parameters that affect the students' grades in the level exam. We discuss, compare, and evaluate the ML algorithms using our dataset.

We used a linear regression algorithm because it is a simple regression algorithm; it is fast to train and showed a good performance since our output variable (Ucomputer grade in computer level exam) for our data is a linear combination of the inputs.

We used WEKA to evaluate the linear regression on our problem before moving onto more complex algorithms in case it performs well. By using WEKA we find that the following formula can predict the Linear regression for Ucomputer:

0.9 * Tcomputer + 5.48

With
Degrees of freedom = 3560
R^2 value = 0.76328
Adjusted R^2 = 0.76322
SE of Coef = 0.00837.

The result obtained by WEKA minimizes the square of the absolute sum of the learned coefficients, which is equal to 0.00837, which gives us a good performance of the prediction for the student's grade in the level exam.

We used WEKA Tool to compute and visualize the results. Table 3 represents the results of EM algorithm. We used a different number of clusters (K=3,5,7, and 9), as shown in Table 3. During the first time, we tested our system with a number of clusters equal to 3; then we ran with 5

clusters, and so on. The performance of EM algorithm was evaluated based on the different number of clusters, as illustrated in Figure 3 and Table 3.

Figure 3 illustrates the relationship between the main parameters that affect the student's grade in the level exam using EM Algorithm. As shown in these figures, the values of the student's grade in the level exam are based on gender and computer grade in the Tawjihi.

Table 3 Results For EM Algorithms Using WEKA

Number of Clusters	Results For EM
EM (with K= 3)	GENDER mean 1.5423 1.9997 1.2556 std. dev. 0.4982 0.0178 0.4362
EM (with K= 5)	GENDER mean 1.0157 1.431 2 1.6203 1.9885 std. dev. 0.1243 0.4952 0.4775 0.4853 0.1067 Tcomputer mean 50.7304 49.5465 48.6801 47.3884 48.6634 std. dev. 9.0157 10.0325 6.4894 10.9545 10.0892
EM (with K= 7)	GENDER mean 1.0001 1.531 1.9301 1.9999 1.4144 1.9917 1.3733 std. dev. 0.0109 0.499 0.255 0.0101 0.4926 0.0909 0.4837 Tcomputer mean 50.0563 48.1192 54.167 49.1993 50.2886 43.808 48.9976 std. dev. 9.9175 6.4613 10.6589 3.812 5.8257 8.4778 9.5035
EM (with K= 9)	GENDER mean 1.1065 2 1.1186 1.9062 1.5372 1.6329 1.1853 1.8614 1.896 std. dev. 0.3084 0 0.3233 0.2916 0.4986 0.482 0.3886 0.3456 0.3053 Tcomputer mean 50.8262 48.4665 50.1551 49.5672 50.5986 48.1678 48.0511 46.2655 50.9372 std. dev. 7.2881 6.216 10.2293 7.5518 8.461 10.1477 10.4812 8.1455 10.7022

In EM algorithm, the best parameters are selected based on their Standard Deviation Values. Table 4 shows the list of the main factors that affect the student's grade in the level exam with their standard deviations.

The second model uses the KSOM algorithm. This algorithm is employed to illustrate the components that affect the student's grade in the level exam. For the KSOM algorithm, the main components that affect the student's grade in the level exam are gender and Tcomputer grades. Figure 4 shows the results.

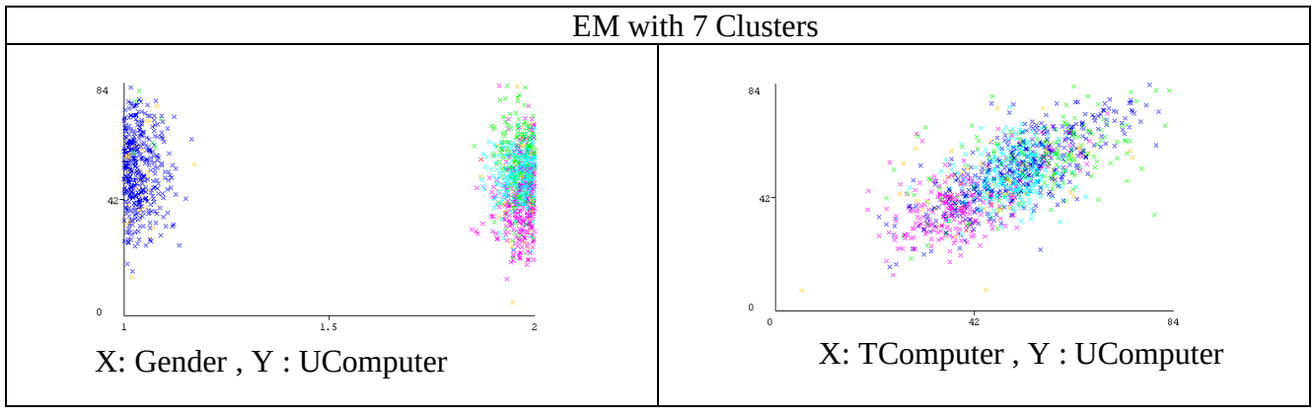
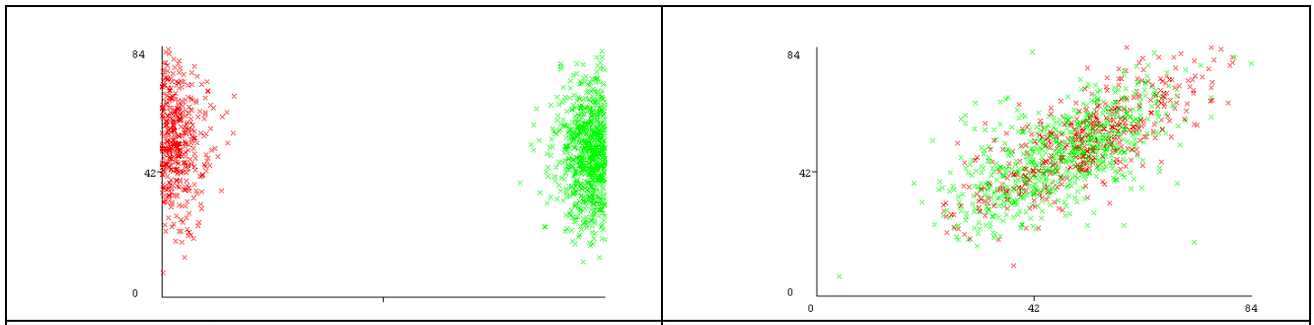


Figure 3 Plotting of the main components that affect the student's grade in the level exam using

Figure 5 illustrates a comparison between the EM and KSOM algorithm. As the figure shows, the predicted model for the two components is highly similar. The performance of gender and Tcomputer on the student's grade in the level exam has the same significant effect. The analysis of the two graphs shows that the two algorithms have the same effect between the potentially used two input parameters gender and Tcomputer.

Table 4 List of the Main Component that Affects Student's Grade in the Level Exam (EM)

Number of Clusters	Standard. Deviation	St Dev. Without subject parameter	Predict Components
3	0.0178	0.0647	Gender
5	0. 0.1067	0.3542	Gender
	6.4894	5.7734	Tcomputer
7	0.0101	0.0007	Gender
	3.812	6.1907	Tcomputer
9	0.2916	0.0001	Gender
	6.216	5.7946	Tcomputer



X: gender , Y : student's grade in level exam

X: Tcomputer, Y : student's grade in level exam

Figure 4: Gender and Tcomputer grade versus student's grade in the level exam (Ucomputer) (KSOM)

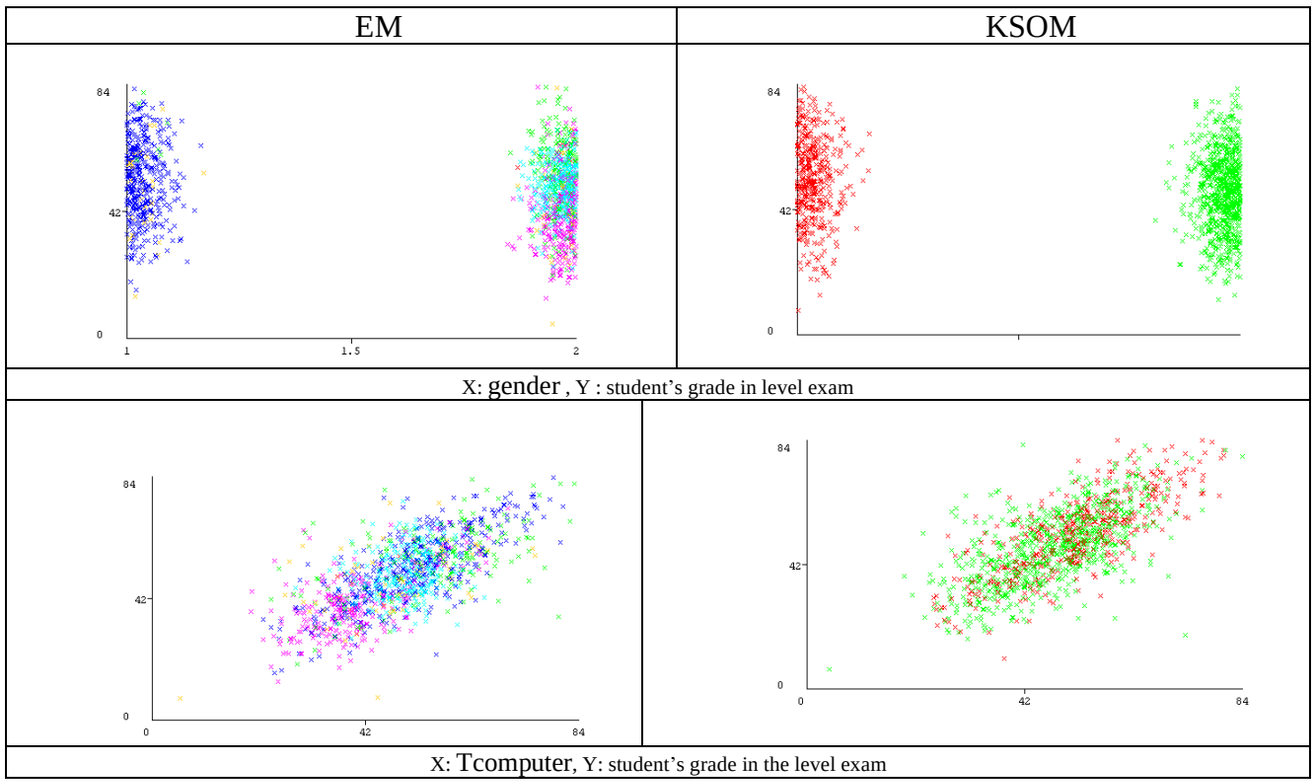


Figure 5: Comparing EM and KSOM Algorithms

The K-means algorithm is applied to the datasets, using different values for k = 3, 5, 7, and 9. Table 5 shows the results of clustering with the different values for K= 3, 5, 7, and 9.

Table 5 Results for K-Means (with K= 3, 5, 7, and 9)

Number of Clusters	Results For K-Means (with K= 3,5, 7 and 9)
K-Means (with K= 3)	Attribute Full Data (3709.0) 0 (854.0) 1 (450.0) 2 (2405.0) GENDER 1.6484 1 1 2 CUM_AVG 64.1844 54.7473 64.9414 67.3938 Tarabic 50.8455 45.8853 54.9209 51.8443 Tenlish 44.2109 36.5038 54.1557 45.0869 Tcomputer 49.1634 47.3982 56.2885 48.457 UArabicl 51.0849 45.8045 54.959 52.235 UEnglishl 44.0855 36.2538 53.6138 45.0837 UComputer 49.6353 48.02 56.5191 48.9209
K-Means (with K= 5)	Attribute Full Data (3709.0) 0 (614.0) 1 (384.0) 2 (818.0) 3 (1587.0) 4 (306.0) GENDER 1.6484 1 1 2 2 1 CUM_AVG 64.1844 57.9077 52.6525 75.3455 63.2952 66.026 Tarabic 50.8455 52.7747 38.4161 59.4462 47.9259 54.7223 Tenlish 44.2109 37.6866 37.8639 56.6992 39.1015 58.3824 Tcomputer 49.1634 49.1097 46.3109 52.1813 46.5373 58.4024 UArabicl 51.0849 52.9928 37.8905 59.7137 48.3802 54.7748 UEnglishl 44.0855 37.6593 37.1361 57.1034 38.8882 57.8558 UComputer 49.6353 49.7894 46.7155 52.4327 47.1108 58.6052
K-Means (with K= 7)	Attribute Full Data (3709.0) 0 (464.0) 1 (310.0) 2 (691.0) 3 (531.0) 4 (267.0) 5 (263.0) 6 (1183.0) GENDER 1.6484 1 1 2 2 1 1 2 CUM_AVG 64.1844 64.192 54.109 76.4291 63.2783 44.0738 67.1149 63.9636 Tarabic 50.8455 52.2382 36.8119 59.8401 38.3298 51.6671 54.9624 53.2399 Tenlish 44.2109 36.7266 36.1848 58.2685 40.1408 43.251 59.8399 39.6076 Tcomputer 49.1634 49.4276 46.3289 52.6644 45.2934 49.0794 58.5829 47.4193 UArabicl 51.0849 52.6596 36.7272 60.2575 39.8204 50.737 55.0659 53.1214 UEnglishl 44.0855 36.8287 35.7039 58.9528 40.067 42.3675 59.3841 39.2344 UComputer 49.6353 50.056 46.7835 52.9087 45.7308 49.4722 58.9534 48.0235
K-Means (with K= 9)	Attribute Full Data (3709.0) 0 (258.0) 1 (228.0) 2 (691.0) 3 (531.0) 4 (221.0) 5 (201.0) 6 (1183.0) 7 (107.0) 8 (289.0) GENDER 1.6484 1 1 2 2 1 1 2 1 1 CUM_AVG 64.1844 59.8225 51.4314 76.4291 63.2783 42.4452 66.4838 63.9636 65.7059 65.893 Tarabic 50.8455 51.4279 35.5557 59.8401 38.3298 51.6838 57.9555 53.2399 56.5441 46.3805 Tenlish 44.2109 30.4357 34.506 58.2685 40.1408 43.1999 44.96 39.6076 69.4579 47.7799 Tcomputer 49.1634 47.1613 46.1012 52.6644 45.2934 49.6889 56.5781 47.4193 63.8717 48.2404 UArabicl 51.0849 51.7431 35.1674 60.2575 39.8204 50.6456 58.1773 53.1214 56.3422 46.9404 UEnglishl 44.0855 30.4988 34.2823 58.9528 40.067 42.0842 45.1036 39.2344 69.3178 47.1226 UComputer 49.6353 47.676 46.5076 52.9087 45.7308 50.1464 57.0907 48.0235 63.6668 49.0263

Based on the analysis of the result of K-Means, we find that the most factors that affect the student's grade in the level exam are the result of the computer course in Tawjihi (Tcomputer) (Table 5). Referring to the achieved results, Table 5 presents a summary of the key attributes that affect the student's grade in the level exam using the three different algorithms.

Referring to the results shown in Table 6, the K-Means algorithm shows that CUM_AVG, Tenglish, and Tcompute are the most common parameters that affect the student's grade in the level exam. When we use both EM and KSOM algorithms, two parameters are considered, which are: Gender and Tcomputer (Table 7). At the same time, the K-Means algorithm includes a distinguished component, the CUM_AVG. It is clear that all three algorithms show intersection and provide different information. In general, the analysis concludes that Tcomputer is a common parameter that affects the student's grade in the level exam.

By using WEKA, we find that the actual average of the student's grade in the level exam is equal to 49.6353. The results show that the K-Means can be successfully used to give a more accurate prediction for increasing the student's

grade in the level exam compared to the average of the actual data, which is 49.6353 (Table 8).

Table 6 K-Means - The Most Factors that Affect the Computer Level Result

Number of Cluster	Parmeters
3	Tcomputer
5	CUM_AVG, Tenglish and Tcomputer
7	CUM_AVG, Tenglish and Tcomputer
9	Tenglish and Tcomputer

Table 7 Summary of the Main Components that Affect the Computer Level Result Using the 3 Algorithms

K-Means	EM	KSOM
CUM_AVG, Tenglish and Tcomputer	Gender and Tcomputer	Gender and Tcomputer

Table 8 A Relation Between No. of Cluster, Sum of Squared Errors and the Student's Grade in the Computer Level Exam Using K-Means

No. of Clusters	Sum Of Squared Errors (SSE)	Number Of Iterations	student's grade in level exam for computer is (49.6353)
3	319.8002246319065	16	56.5191
4	353.5744326617288	6	50.953
5	240.38699317691064	17	58.6052
6	253.00159228731195	16	56.5191
7	215.58737786916973	41	58.9534
8	208.46352694465233	41	62.5657
9	203.7570220482533	41	63.6668
12	174.06781954211337	96	63.4604
15	156.2830245315655	54	55.0647
20	136.53349982348624	67	62.1059
25	124.69899067623594	36	63.7429
30	83.77	17	63.3709
50	62.3	16	67.23

In summary, this study reviewed previous researches on educational data mining and predicting students' performance. These different studies delve into analyzing the data mining techniques and parameters that will help predict student performance in the level exams.

We tested three different algorithms for comparative evaluation of finding the main parameters that affect the student's grade in the level exam using the WEKA tool. Based on the result found, it is clear that the results of the performance of EM algorithm are the most accurate and effective for finding various parameters affecting the student's grade in the level exam. The achieved results exhibit Logistic linear regression, K-Means, and KSOM are the most adequate algorithms for predicting and improving the student's grade in the level exam.

Based on the results from the testing and evaluation, the researchers found out that applying the different data mining algorithms to our datasets effectively predicts and improves the student's grade in the level exam increases the performance of the student's grade in the level exam from 49.6353 to 67.23.

Our analysis shows that there is a slight difference between the data mining algorithms. The output of each data mining algorithm is similar, and the performance of each of them is suitable for the prediction and improving the grade of the student in the level exam.

In addition, our prediction model will help the University take the required actions at the right time and improve the students' performance. The records of newly admitted students will be fed to the model. Those who have less chance to pass the level exam will be advised by their supervisors to pay more attention to the preparation of the exam or take supporting courses to improve their chances to pass the exams.

Based on the analysis of the data and interpretation of the results, we can improve the computer level exam's performance by accepting more female students and students with high computer results in Tawjihi.

Interpreting the result of the data mining techniques tells us that we can increase the average student's grade in the level exam from 49.6353 to 67.23 by working on the two factors that affect Computer-level exams. These factors are Computer results in Tawjihi and Gender.

The results can be used and utilized by the Student Admission, Academic Affairs, and Enrolment Office at the University for planning purposes:

1-Admit policy for the students:

- Accepting more females than male
- Accepting students with high results in Computer Exam.

2- Based on the results, the University can exclude some students from the level exams. This will make a profit from the use of resources, labs, technicians, staff, and financial and human resources.

3- Effective management of staff load.

CONCLUSIONS

This research aims to find out the most useful attributes, which are used for predicting the performance of students in the level exam, and determine which data mining techniques and parameters are best to improve the accuracy of the

prediction mechanism in the educational information system.

This paper discussed developing a prediction model for finding the main parameters that affect the students' grades in the level exam.

We used seven input parameters to predict the student's grade in the level exam using different data mining algorithms (Logistic Regression, EM, KSOM, and K-Means). The actual input parameters consist of 7 parameters and one output student's grade in level exam (Ucomputer) with 5621 student records.

Results showed that using data mining techniques effectively predicts the main parameters that affect students' grades in the level exam. The analysis shows that Logistic linear regression, K-means, and KSOM algorithms are the most accurate algorithms to predict the student's grade in the level exam. At the same time, EM is useful for predicting the main parameters that affect the student's grade in the level exam.

In general, data mining techniques are very effective tools in predicting the student's grade in the level exam as well as the main factors that affect and improve the performance of student's grade in the level exam. The results can be used by the student admission, academic affairs, and enrolment office for planning purposes. Our study may be expanded to include an additional range of parameters to improve the prediction of the students' grades in the level exam.

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Diallel Analysis and Heritability of Fruit Quality Traits in Melon (*Cucumis Melo L.*) Inbred Lines

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ABSTRACT

The present study was conducted at Swaida agricultural research center, Syria, during the season 2019, to estimate the genetic components of six melon (Cucumis melo L.) inbred line and their 30 F1s hybrids produced by complete diallel mating design, to evaluate some fruit quality traits (dry matter, total soluble content TSS, total sugar, carotene, and vitamin C) using Hyman analysis approach. The results showed that all the studied traits were controlled by overdominant gene effect, and most of the parents carried more dominant genes than recessive, since the variation components due to non-additive effects of genes (H1) was greater than the variation due to additive effects of genes (D) for all studied traits. The low values of narrow-sense heritability indicating the importance of the non-additive gene effect for the studied traits. According to the values of the variance and covariance for parents with their offspring (Wr+Vr) showed that P5 (IL-CM116) carried the most dominant genes for most of the studied traits, while P2 (IL-CM106) have the most recessive genes for all studied traits.

Keywords: Cucumis Melo, Melon, Diallel, Hayman Analysis, Narrow sense Heritability.

الملخص

أجريت هذه الدراسة في مركز البحوث العلمية الزراعية بالسويداء سوريا، خلال الموسم(2019)، لتقدير المكونات الوراثية لست سلالات من البطيخ الأصفر (Cucumis melo L.) و(30) هجيناً ناتجة عن التهجين التبادلي الكامل، لتقييم بعض صفات الثمار النوعية (المادة الجافة، المواد الصلبة الكلية الذائبة(TSS)، السكريات الكلية، محتوى الثمار من (الكاروتين وفيتامين (C))باستخدام تحليل (هايمان Hyman). أظهرت النتائج أن الصفات المدروسة تخضع لتأثير السيادة الفائقة للجينات، وأن معظم الآباء يحملون جينات سائدة أكثر من المتنحية، حيث كانت مكونات التباين العائدة للتأثير غير المضيف للجينات (H1) أكبر من التباين العائد للتأثير المضيف للجينات(D) للصفات المدروسة. وتشير القيم المنخفضة لدرجة التوريث بالمعنى الضيق إلى أهمية التأثير الجيني غير المضيف في وراثة الصفات المدروسة. أظهرت مجموع قيم التباين والتباين المشترك ما بين الاباء والهجن الناتجة عنها (Wr + Vr) أن الأب P5 (IL-CM116) يحمل أكبر عدد من الجينات السائدة لمعظم الصفات المدروسة، بينما يمتلك P2 (IL-CM106) أكثر الجينات المتنحية للصفات المدروسة.

الكلمات المفتاحية: البطيخ الأصفر، التهجين التبادلي، تحليل هايمان، درجة التوريث الضيقة.

INTRODUCTION

Melon (*Cucumis melo* L., 2n=2x=24) is one of the most economically important cucurbitaceae family species (Burger *et al.*, 2003; Saha *et al.*, 2018). The origin of melon was firstly considered from Africa. However, recent studies indicated that cucumber and muskmelon are of Asian origin, with a wide diversity of Cucumis melo wild species in China and India (Sebastian *et al* 2010). Melon fruit is one of the most summer fruits because of its high nutritive and medicinal value, musky flavor, sweetness, and aroma (Abo Sedera *et al*., 2016).

The great diversity of melons around the world and the several botanical types of fruits and chemical content play an important role in marketing good fruit genotype market-standard size, good flesh thickness, small internal cavity, high flesh firmness, and high soluble solids content (Nunes *et al.*, 2005), in addition to the high total sugar content, carotene and the level of vitamin C (Abo Sedera *et al*., 2016).

The improvement program for fruit quality trait of melon has to focus on more than one melon type since the breeding program of melon is based mainly on exploiting the natural sources of germplasm by means of selection and hybridization followed by selection (Mliki *et al*.,2001).

Selection and hybridization are the two most methods in plant breeding and crop improvements. The successful selection depends mainly upon the extent of wide genetic background (Singh, 1998). The utilization of divergent genotypes in diallel hybridization design can create a higher genetic base. In addition, the information about gene interaction that covered the main agronomic characters that play an important role in genetic improvement can be established by diallel analysis since the study of the performance of parents and their hybrids gives good information about the inheritance of economic traits (Pandey*et al*., 2010).

The diallel meeting design gives breeders the ability to study all combinations of the parents' crosses. The analysis of diallel can conduct heterosis, general and specific combining ability

using Griffing approach, and study the genetic control that covered the studied traits by using Hayman approach (Cardoso *et al.*,2015)

The Hayman numerical approach of diallel analysis provides good information about additive and dominance gene effect and the allied statistics. Genetics largely depends upon the relative magnitude of these two components in the prediction of the gene interaction that controls the desirable traits (Walton, 1968). The improvement of the fruit quality traits in melon depends mainly on detecting the genetic interaction that controls them and the suitable breeding program determined by Hayman's approach (Saha *et al.*, 2018).

The aim of this study was to estimate the genetic parameters that control some fruit quality traits of melon in a set of 6 melon inbred lines as parents and their 30 F_1diallel crosses.

MATERIALS AND METHODS

The present study was carried out in the experimental field at Swaida research center, Syria. During the summer season of 2019 to study the genetic behavior of some quality traits for six inbred melon lines.

▪ Plant Materials

Six inbred melon lines were obtained from the General Commission's vegetable department for Scientific Agricultural Researches (GCSAR), Syria. The source of these lines was some of the local melon populations. The six inbred lines (Table 1) were crossed in a diallel mating design to obtain 30 F_1 hybrids. During the 2019 season, the 36 muskmelon genotypes (6 parents and 30 F_1) were evaluated for some fruit chemical quality traits.

Table 1 The Six Inbred Melon Lines and Their Parental Number

Genotype name	Parental Number
IL-CM104	P1
IL-CM106	P2
IL-CM108	P3
IL-CM113	P4
IL-CM116	P5
IL-CM118	P6

▪ Experimental Design

The 36 melon (6 parents and 30F_1) genotypes were evaluated in Randomized Complete Blocks Design (RCBD) with four replications. The total number of experimental plots was 144; each experimental plot was one row of 8 meters in length and 1.5m between lines. The total number of plants in each row was 10 plants, and the distance between plants in each row was 80 cm.

All the cultural practices were done as recommended for melon, and the control of diseases and insects was practiced according to the Ministry of Agriculture's recommendation.

▪ Measurements

All the measurements were carried out on 5 ripe fruits, which were selected randomly from each experimental plot. These fruits were used to determine the following fruit quality traits.

- **Dry Matter**

According to Kirk and Sawyer (1989), the dry matter was determined by placing 100g of juice in the oven at 80° until the weight stabilizes**.**

- **Total Soluble Solid (TSS)**

It was measured using a refractometer (Matest- 24048 -Italy).

- **Total Sugar**

The total sugar content in the experimental plot's fruit is expressed by titration of Fehling's A and B stock solution and Methylene Blue as an indicator until the blue color disappears (Takahashi, 1959).

- **Carotene**

The total carotenoids content in the fruit of the experimental plot was determined using the Spectrophotometer (UK-106) according to the method described by Beerh and Siddappa (1959) at wavelengths 470, 645, and 662.

- **Vitamin C**

The vitamin C contents were determined according to the method described by Ismail et al. (2014) by titration using Iodine solution and starch as an indicator.

▪ **Statistical Analysis:**

Diallel analysis for inbred line parents and their F1 was carried out according to Hayman's (1954) approach. Hayman partitioned the total sum of square due to genotypes into four components: The additive component with (P-1) degree of freedom, non-additive effect with p (p-1)/2 degree of freedom, maternal and reciprocal effects with (p-1), and p(p-1)/3 degree of freedom, respectively; where p is the number of parents involved in crosses. The non-additive component

is further partitioned into b1, b2, and b3 with 1, p-1, and p (p-3)/2 degrees of freedom, respectively.

Hayman's method involves the computation of the analysis of variance, variance, and covariance for the parents with their offspring and the establishment of the graph of Vr-Wr.

Depending on data analysis, the following genetic components were estimated: (i) Variation due to additive effects of genes (D); (ii) The covariance of additive and non-additive effects in each array (Fr); (iii) The mean of "Fr" over the arrays (F); (iv) The variation components due to non-additive effects of genes (H1); (v) The predicted ratio of positive and negative genes in the parents (H2); (vi) The dominance effects (as the algebraic sum over all loci in heterozygous phase in all crosses).

The genetic components of variation were used to estimates the following statistics:

- $(H1/D)^{1/2}$: The mean degree of dominance over all loci, If $(H1/D)^{1/2}$ in the range between 0-1 indicating partial dominance effect, greater than 1 donates over dominance effect.
- H2/4H1: The proportion of genes with positive and negative effects in the parents. The value should have a maximum of 0.25 when the positive and negative alleles in a symmetrical distribution. Asymmetrical distribution in a value less than 0.25.
- *$(Kd/Kr)=((4DH1)^{1/2} + F) / ((4DH1)^{1/2} – F)$:* The proportion of dominant to recessive genes.
- (h^2/H2): Number of groups of genes that control the trait.
- Coefficient of correlation (r) between Wr + Vr and Yr: If the correlation is negative, it tends to increase the trait.
- *(1/4 D/(1/4(D+H1-F)+E))*100*: Narrow sense heritability

The Wr/Vr graph is the other powerful tool in Hayman's analysis. Parents who possess smaller values of (Wr+Vr) have more of the dominants genes and lie near the origin point, and those with higher values of (Wr+Vr) possess the most recessive genes and lie furthest from the origin point. The degree of dominance is determined by the intercept of Wr/Vr regression line.

Hayman diallel analysis was carried out using AGD_R software, a free software developed by International Maize and Wheat Improvement Center (CIMMYT).

RESULTS

According to the Hayman diallel approach, the analysis of variance showed highly significant differences among the 36 genotypes (6 parents and 30 F1 crosses) for all studied fruit quality traits (Table2). These results indicated that the genetic parameter estimates could be performed on all the observed characters. Significant mean squares were observed for additive and non-additive components for all studied characters indicating the importance of both gene actions in the inheritance of these traits. The non-additive components were further partitioned into b1 with 1 degree of freedom, b1 was highly significant in total sugar and carotene traits implying the presence of directional dominance, b2 with p-1 degree of freedom, were highly significant in all studied trait except vitamin C indicating gene asymmetry among parents. In other words, some parents have more dominant genes than others, b3 with p*(p-2)/2 degree of freedom, b3 were highly significant for all studied traits showing that dominance effect is specific to some individual crosses.

Table 2 Mean Square for Hyman Diallel Analysis for Fruit Quality Traits

Source of variance	df	Dry mater	TSS	Total Sugar	Caroten	Vitamine C
Replication	3	0.28	0.970	0.520	56.67	489.748
Genotype	35	4.79**	1.984**	2.305**	184.734**	847.645**
Additive	5	4.59*	4.080**	2.598**	776.388**	1081.272*
Non-Additive	15	5.16**	2.283**	3.507**	127.703**	867.023**
b_1	1	0.003	1.176	20.053**	461.781**	629.068
b_2	5	6.72***	3.985**	2.601**	139.458**	455.019
b_3	9	4.87**	1.460**	2.172**	84.053*	1122.353**
Maternal	5	6.65**	0.525	1.150	61.549	308.442
Reciprocal	10	3.40*	1.218*	0.934	36.047	971.367**
Error	105	1.46	0.545	0.781	33.092	377.200

*and **, significant and highly significant at 5 and 1% respectively.

▪ Gene Interaction:

The regression coefficient test b (Wr,Vr) was not significant for all studied traits (Table 3). That means no interaction among genes controlling these traits. These results indicated that one of Hayman's diallel assumptions could be met.

▪ Estimation of Genetic Components:

- The Effect of Additive and Dominant Gene Action:

The estimation of additive genetic components D and dominance components H1 and H2 showed highly significant differences for dry mater, TSS, and carotene, indicating the importance of additive and non-additive effects in the inheritance of these traits. On the other hand, only the dominance components H1 and H2 were highly significant for total sugar and vitamin C, suggesting that the non-additive effect plays an important role in the inheritance of these two traits.

- The Mean Degree of Dominance:

The degree of dominance ($(H1/D)^{1/2}$) was 1.51, 2.03, 3.8, 1.32, and 2.5. Since these values were >1, the overdominance effect directs the inheritance towards plants that contains a high level of dry matter, TSS, total sugar, carotene, and vitamin C, respectively.

- The Proportion of Genes with Positive and Negative Effects:

The proportion of genes with positive and negative effects ($H_2/4H_1$) was less than 0.25 (Table 3), indicating gene asymmetry and unequal distribution for alleles that increased and decreased all studied traits except vitamin C. These results were in the same trend with significant and non-significant values of b2 which indicates asymmetrical and symmetrical gene distribution, respectively.

- The Proportion of Dominant to Recessive Genes:

The proportion of Dominant to Recessive Genes (KD/KR) was >1 for all studied traits (Table 3), showing that the six parents used in this study carry more dominant genes than recessive genes for all traits. This was supported by F's positive values, which indicates that there were more dominant alleles than recessive alleles in the parents used in this study. On the one hand, the correlation coefficient r between parental mean Yr and the value of (Vr+Wr) was negative for all studied traits except dry matter. The negative values of r indicating that dominance tends to increase traits. On the other hand, the positive value of r for the dry matter trait indicates that dominance tends to decrease the dry matter contents.

Table 3 Estimation of Genetic Parameter for Melon Fruit Quality Traits Using the Diallel Analysis of Hayman Method

Genetic parameters	Dry mater	TSS	Total Sugar	Caroten	Vitamin C
Covariance-variance regression (b(Wr, Vr))	0.93_{NS}	0.47_{NS}	0.307_{NS}	0.866_{NS}	0.37_{NS}
Additive effect (D)	1.76**	0.449**	0.119_{NS}	71.19**	144.16_{NS}
Dominance effect (H_1)	3.99_{NS}	1.85**	1.72**	124.41**	902.1**
Proportion of dominance due to positive and negative effect of genes (H_2)	3.44**	1.76**	1.69**	112.36**	903.22**
F_r mean (F)	1.99_{NS}	0.88_{NS}	0.311_{NS}	59.44**	195.95_{NS}
F_1 deviation from the average parent (h^2)	-0.19_{NS}	0.08_{NS}	2.68**	60.05**	34.54_{NS}
Environment (E)	0.365_{NS}	0.14_{NS}	1.93_{NS}	8.43**	95.08**
Mean degree of dominance ($(H1/D)^{1/2}$)	1.51	2.03	3.80	1.32	2.50
Proportion of positive genes to negative genes ($H_2/4H_1$)	0.215	0.23	0.245	0.225	0.25
The proportion of dominant to recessive genes (K_d/K_r)	2.21	2.87	2.044	1.93	1.74
Number of groups of genes (h^2/H_2)	-0.05	0.04	1.58	0.53	0.038
Coefficient of correlation (r) between Wr + Vr and Yr	0.69	-0.82	-0.87	-0.77	-0.69
Narrow-sense heritability (h^2_{NS})%	33.71	14.42	1.55	41.90	11.70

NS: not significant, *and **, significant and highly significant at 5 and 1% respectively.

- Number of Groups of Genes Controlling the Studied Traits.

The number of gene groups controlling the fruit quality traits was estimated from $h^2/H2$ values. These values were less than 1 for all studied traits except total sugar. Indicating that these traits are covered by one group of genes, while the total sugar trait ($h^2/H2=1.58$) is controlled by two main groups of genes (Table3).

- Direction and Order of Dominance

The order of dominance of the 6 parents to dry matter was IL-CM104, IL-CM118, IL-CM113, IL-CM116, IL-CM108 and IL-CM106 (Table 4). The parent IL-CM106 possesses the most recessive gene because it is the most distance from the point of origin. In the meantime, IL-CM104 contained the most dominant genes since it is the closest to the point of origin. The regression line of Wr-Vr graph intercepts the Wr axis under the origin 0, indicating the overdominance effect on dry matter inheritance (Figure1).

The order of dominance of parents for total soluble contents (TSS) was IL-CM113, IL-CM116, IL-CM104, IL-CM108, IL-CM118 and

IL-CM106 (Table4). IL-CM106 carried the most recessive genes, while IL-CM113 carried the most dominant genes. The regression line of Wr -Vr cut Wr axis under the origin (0), indicating overdominant gene action (Figure 2).

Regarding the total sugar trait, the parent 5 (IL-CM116) carried the most dominant genes since it was the closest to the origin point, while parent P2 (IL-CM106) has the most recessive genes. The regression line of Wr-Vr intercepted Wr axis under the origin, indicating over dominance gene action covering total sugar inheritance (Figure3).

The order of dominance of parents for Carotene was IL-CM116, IL-CM113, IL-CM108, IL-CM118, IL-CM104, and IL-CM106. The parents IL-CM116 and IL-CM106 carried the most dominant and recessive genes since they were the closest and furthest to the point of origin, respectively. The Wr- Vr regression line cut the Wr axis over the point of origin indication partial dominant gene effect (Figure4).

According to the Wr+Vr values for Vitamin C content, the order of dominant parent was IL-CM116, IL-CM108, IL-CM118, IL-CM113, IL-CM104, and IL-Cm106. Parent 5 (IL-CM116) possesses the most dominant genes, and parent 2(IL-Cm106) has the most recessive gene of this trait. The partial dominant effect was controlling the inheritance of Vitamin C fruit contents since the Wr-Vr regression line cutting the Wr axis over the point of origin (Figure 5).

- **Heritability**

The narrow-sense heritability was less than 50% for all studied traits (Table 3), indicating the predominant non-additive gene action for all studied traits. These results were supported by the positive values of "F' suggested that the heterosis breeding might be the good manner to get higher quality trait of melon.

DISCUSSION

Diallel analysis is the most balanced and systemic experimental design to examine continuous variation. The genetic knowledge about the parental population becomes available in the early generation, which plays an important role in defining the breeding strategy without losing much time (Debnath, 1988).

The estimation of the genetic parameter using diallel crosses analysis can be carried out if there is a significant difference among genotypes using the variance of the observed variable (Singh & Chaudhary 1979).

In the present study, the fruit quality traits showed highly significant differences among the studied genotypes (6 parents and 30F_{1S}), leading to the further analysis of the Hyman approach that can be done. These results were in agreement with Mohammadai et al. (2014) and Abo Sedera et al. (2016).

Table 4 Wr+Vr Values of the Six Parents for Melon Fruit Quality Traits.

Genotype	Dry mater	TSS	Total Sugar	Carotene	Vitamin C
IL-CM104(p1)	-0.01	0.32	0.53	85.18	298.28
IL-CM106(P2)	3.57	1.22	1.81	129.08	427.53
IL-CM108(p3)	1.82	0.38	0.23	56.37	37.01
IL-CM113(p4)	0.31	0.13	0.22	36.65	208.86
IL-CM116(p5)	0.62	0.15	0.07	7.73	35.74
IL-CM118(p6)	0.20	0.41	0.23	59.37	158.28

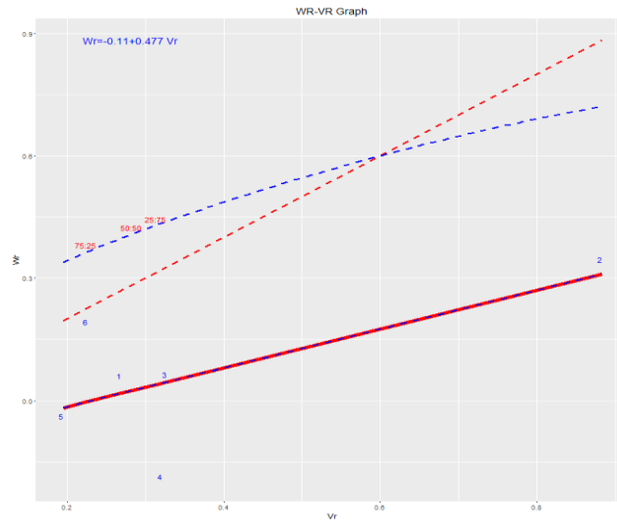

Figure 1: The graph of variance (Vr) and covariance (Wr) for dry mater of fruit in the F_1 generation of melon genotypes. [1:parent IL-CM104, 2: parent IL-CM106, 3: parent IL-CM108, 4:parent IL-CM113, 5: parent IL-CM116, 6: parent IL-CM118].

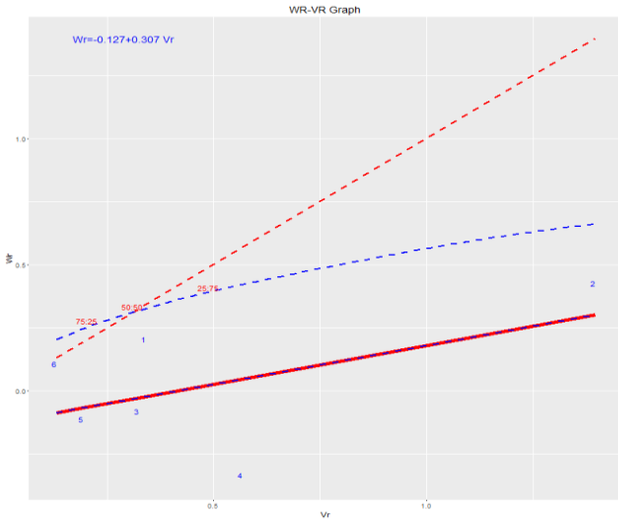

Figure 2: The graph of variance (Vr) and covariance (Wr) for TSS of fruit in the F_1 generation of melon genotypes. [1:parent IL-CM104, 2: parent IL-CM106, 3: parent IL-CM108, 4: parent IL-CM113, 5: parent IL-CM116, 6: parent IL-CM118].

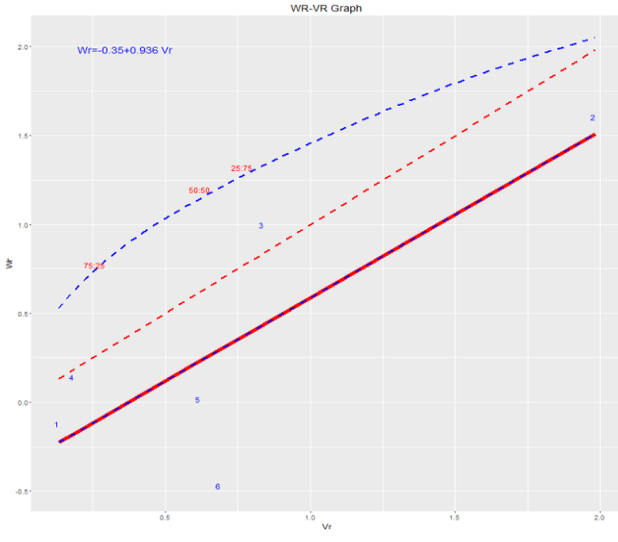

Figure 3: The graph of variance (Vr) and covariance (Wr) for total sugar of fruit in the F1 generation of melon genotypes. [1:parent IL-CM104, 2: parent IL-CM106, 3: parent IL-CM108, 4: parent IL-CM113, 5: parent IL-CM116, 6: parent IL-CM118].

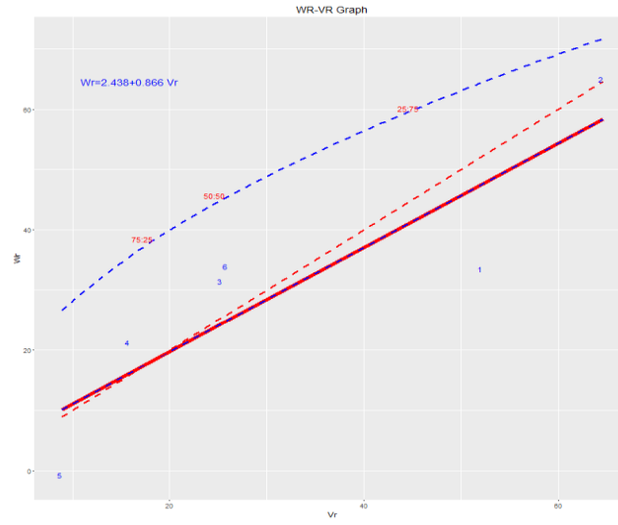

Figure 4: The graph of variance (Vr) and covariance (Wr) for Carotene of fruit in the F_1 generation of melon genotypes. [1:parent IL-CM104, 2: parent IL-CM106, 3: parent IL-CM108, 4: parent IL-CM113, 5: parent IL-CM116, 6: parent IL-CM118]

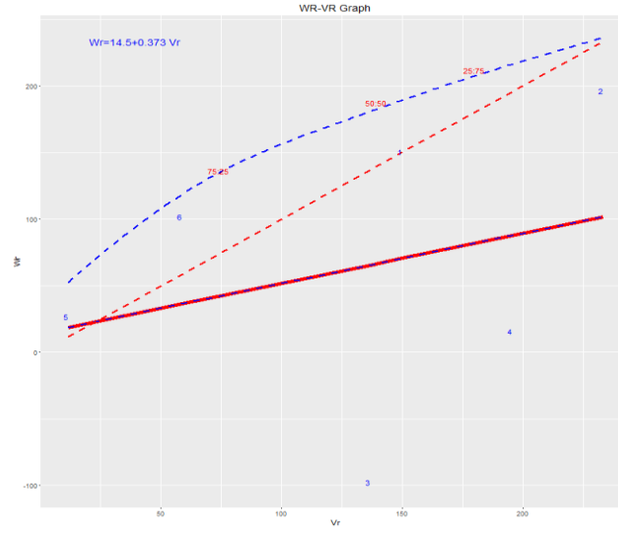

Figure 5: The graph of variance (Vr) and covariance (Wr) for Vitamin C of fruit in the F_1 generation of melon genotypes. [1:parent IL-CM104, 2: parent IL-CM106, 3: parent IL-CM108, 4: parent IL-CM113, 5: parent IL-CM116, 6: parent IL-CM118].

The genetic interaction among the genes that controlled the studied traits can be seen from the value of the regression coefficient b (Wr,Vr). If the value is not significantly different from one, indicating no interaction among the genes (Sousa and Maluf 2003). In the study, the b values were not significant for all studied traits. Regarding these results, one of the Hayman diallel assumptions can be met.

The mean degree of dominance $(H1/D)^{½}$, which was over than 1 for all fruit quality traits, confirmed the overdominance action. These

results were supported by the dominant component of variance H1, which was higher than the additive component D for all studied traits. In addition, the existence of overdominant gene action and the low values of the narrow sense heritability suggested that selection in the segregation generation to improve fruit quality traits depends mainly on heterotic individual plants. These results were in accordance with (Abou kamer et al., 2015; Glala et al., 2012; Iban et al., 2007; Mohammadi et al., 2014; Reddy et al., 2013; and Shamloul & Askar, 2011).

The proportion of dominant to recessive genes in the 6 inbred line parents was estimated by the value of Kd/Kr. This value was > 1 for all studied traits, indicating that there were more dominant than recessive genes in the parents used in this study. On the other hand, the proportion h^2/H1 was less than 0.25 for all studied traits except Vitamin C. The values of h^2/H1 less than 0.25 showed the unequal distribution of dominant genes among parents. In the same trend, the number of dominant genes among parents is determined by the value of Wr+Vr. Parents who showed the lowest value of Wr+Vr carried the most dominant genes that controlled the studied trait. According to that, parent P2 (IL-CM106) carried the most recessive genes for all studied traits. On the other hand, parent P5 (IL-CM116) was the most dominant parent for all studied traits except TSS. In contrast, parent P4 (IL-CM113) carried the most dominant genes for the TSS trait. These results were in the same trend as Bayoumy et al. (2014) and Abo Sedera et al. (2016).

The correlation coefficient r between parental mean Yr and the value of (Vr+Wr) was negative for all studied traits except dry matter. The negative values of r indicating that the dominant alleles work to increase the mean value of TSS, Total sugar, carotene, and vitamin C. The parent P5 (IL-CM116) showed the most dominant genes for Total sugar, carotene, and Vitamin C, indicating the possibility of obtaining a line with greater magnitude of these traits by selecting P5 segregation populations. In the same trend, the r between parental mean Yr and the value of (Vr+Wr) was negative for the TSS trait. The parent P4 and P5 showed very close values of (Vr+Wr), thus indicating that these two parents play an important role in improving the TSS trait since they carried the most dominant alleles. On the other hand, the positive value of r between parental mean Yr and the value of Vr+Wr for dry matter trait indicates that the recessive alleles tend to increase the mean value of these traits. The highest value of dry matter can be obtained from the high concentration of recessive alleles contained in P2 (IL-CM106). These results were in the same trend as Cardoso et al. (2015).

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Market Information System for Farmers*

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ABSTRACT

Today, Palestinian farmers in small to medium-sized farms and multifunctional farms are rare to use market information systems for various reasons, like cost, scarcity of these systems, lack of experience and knowledge, the user interface language, and the complexity of the available such systems. The development of a MISF that uses new technologies, such as web-based and smart devices, is based on the initial information related to the local agricultural community, a questionnaire about the role of market information systems for Palestinian farmers was used, different statistical methods were used to analyze the data collected by the questionnaire for this study. Different users or stakeholders in the agricultural sectors can use the system. The application of MISF was successfully implemented using web technology and smart devices and tested, where all different scenarios were recorded. In this research, a descriptive approach was used to analyze the agricultural information marketing system. First, data related to our system was gathered using a literature review of research, reports, questionnaires, and site visits. This paper aims to address some of the problems facing the farmer markets. The proposed system will facilitate trade by creating a capacity for sellers to contact individual buyers. This system will provide information on what agricultural products are in demand by analyzing consumer consumption and market trends. The system will collect demographic details such as the types of crops grown, crop size, prices, cost, and maybe access to the type of irrigation, soil, and fertilizers as inputs from the farmers as well as other information about crops consumption. The data gathered by the proposed system can be used to advise farmers about needed crops and suggest ways to help them lower costs and improve productivity by using data mining techniques. Survey results indicated the need of farmers and other stakeholders in the agricultural sector for an efficient, easy-to-use MISF. In general, the system will track farmers' daily activities, businesses and provide ongoing support in areas such as labor, costs, yields management, crops consumption, harvest management, and market price discovery. This, in turn, will help to create strong relationships with buyers.

Keywords: Market Information Systems for Farmers, Data Analysis, Agriculture Information System, Web based Application.

الملخص

في يومنا هذا، نادرا ما يستخدم المزارعون الفلسطينيون من أصحاب المزارع الصغيرة والمتوسطة والمزارع متعددة الاستعمال أنظمة معلومات السوق لأسباب مختلفة مثل: التكلفة، وندرة هذه الأنظمة، وقلة الخبرة والمعرفة في التعامل معها، وصعوبة التعامل مع الأنظمة المتوفرة. يعتمد تطوير نظام معلومات السوق للمزارعين الذي يستخدم تقنيات جديدة مثل التطبيقات القائمة على (الويب) والأجهزة الذكية، على المعلومات الأولية المتعلقة بالمجتمع الزراعي المحلي، تم استخدام استبانة حول دور أنظمة معلومات السوق للمزارعين الفلسطينيين، وتم استخدام الأساليب الإحصائية المختلفة لتحليل البيانات التي تم جمعها بواسطة الاستبانة في هذه الدراسة. يمكن لمختلف المستخدمين أو أصحاب المصلحة في القطاعات الزراعية استخدام النظام. تم تنفيذ تطبيق نظام معلومات السوق للمزارعين بنجاح باستخدام تقنية الويب والأجهزة الذكية، كما وتم اختباره، حيث تم تسجيل جميع (السيناريوهات) المختلفة. في هذا البحث تم استخدام المنهج الوصفي لتحليل نظام تسويق المعلومات الزراعية. أولاً، تم جمع البيانات المتعلقة بنظامنا عن طريق مراجعة الأدبيات للأبحاث والتقارير والاستبانات، وزيارة الموقع الزراعية. هذه الورقة، تحاول معالجة بعض المشاكل التي تواجه أسواق المزارعين. سيسهل النظام المقترح التجارة من خلال خلق قدرة للبائعين على الاتصال بالمشترين بشكل فردي. سيوفر هذا النظام معلومات حول المنتجات الزراعية المطلوبة من خلال تحليل استهلاك المستهلك واتجاهات السوق. سيقوم النظام بجمع التفاصيل (الديموغرافية) مثل أنواع المحاصيل المزروعة وحجم المحاصيل والأسعار والتكلفة وربما الوصول إلى نوع الري والتربة والأسمدة كمدخلات من المزارعين سيضاف إلى ذلك معلومات أخرى حول استهلاك المحاصيل. يمكن استخدام البيانات التي تم جمعها بواسطة النظام المقترح لتقديم المشورة للمزارعين حول المحاصيل المطلوبة واقتراح طرق لمساعدتهم على خفض التكاليف وتحسين الإنتاجية، باستخدام تقنيات استخراج البيانات. أظهرت نتائج الاستطلاع ان المزارعين والأطراف المختلفة في القطاع الزراعي بحاجة الى نظام معلومات فعال وسهل الاستخدام. بشكل عام، سيتتبع النظام الأنشطة اليومية للمزارعين، والأعمال التجارية، ويوفر الدعم المستمر في مجالات، مثل: العمالة والتكاليف وإدارة الغلة واستهلاك المحاصيل وإدارة الحصاد واكتشاف أسعار السوق والعلاقة القوية مع المشترين.

الكلمات المفتاحية: نظم معلومات السوق- للمزارع، نظم المعلومات الزراعية، تحليل البيانات، التطبيق القائم على الويب.

INTRODUCTION

An Overview

The importance of the agricultural sector in Palestine stems from its contribution to the food security of Palestinian households and the creation of job opportunities in the local Palestinian market. Furthermore, the agricultural sector is an important driver in the Palestinian economy since it creates job opportunities in the local Palestinian market. In recent years, new business models have emerged for the agricultural markets. However, there is a need for a new advanced market information system to facilitate transactions. Both sides, the consumers and the farmers, need certain information from the markets about agricultural products. For example, consumers may place requests regarding accurate agricultural product information or safety, while farmers may wish to display their products.

The main objective of the study is to develop a market information system for farmers (MISF) and digitize it using web applications and smart devices. This step helps and strengthens the local agricultural system, improves productivity, improves lives, and provides jobs for farmers in Palestine. It also helps provide and create new markets and value chains, bring together a wide range of local and regional stakeholders, and strengthen relationships between farmers and trusted consumers.

The problem of the study lies in the limited applications of information systems in the field of agriculture in general and agricultural marketing in particular. This comes despite the need of the different agricultural sectors for mechanisms by which market information can be exchanged for support in treating disconnected marketing groups such as retailers, wholesalers, consumers, factories, etc., dealing with agricultural products; strengthening supply chains that suffer from disintegration, and limiting mediators and monopolists' control on agricultural markets in light of the farmer's lack to effective communication with traditional markets, whether for agricultural products or production requirements.

Agriculture Sector in Palestine

The agricultural sector is an important driver in the Palestinian economy since it creates job opportunities in the local Palestinian market. The agricultural sector and its activities show that the sector faces many challenges and obstacles and weak agricultural advising and scientific research. The political conflict in Palestine is the most critical of these challenges, characterized by the Israeli practices of land confiscation, control over natural resources, especially water, and restrictions on the mobility of products between Palestinian areas on the one hand; and with international markets on the other, thus increasing the cost of agro production and marketing.

Central markets for crops are spread throughout the West Bank, and there is hardly a governorate devoid of central markets. Up to this date, there are 11 central markets spread in all the governorates of the West Bank, with the exception of Jerusalem and Salfit governorates. However, the market is still under operating procedures, bringing the number of markets to 11 central markets. The central markets are considered one of the pillars of the marketing process for agricultural products from the farmers to every final consumer type. Central markets provide different types of vegetables, fruits, and fresh field crops according to the needs of each governorate. There are also many shops, wholesalers, and mediators working in these markets under the supervision of the municipalities of the city in which the market is located. In late years, the central markets have suffered several problems, the most important of which is the Israeli occupation policy undermining the Palestinian crops; add to this the absence of organization and surveillance from the responsible authorities of these markets.

The agricultural sector is considered a basic pillar in economic activity and plays a fundamental role in economic development. The agricultural sector's main role in developing economic resources is supplying food and other products necessary to the life of the individual and society alike. It also plays an important role in its contribution rate to meet the Palestinian people's food needs.

Study Approach

The study aimed to identify the role of MISF in order to establish and automate a system to improve the reality of markets and manage

products and the agricultural food supply chain to benefit the marketing circles in partnership with the Ministry of Agriculture, the Central Statistics Department, and the Ministry of Higher Education and Scientific Research. The study focused on the marketing, presentation, and utilization of an integrated information that provides valuable data to the farmer about the crops he cultivates. It also provides data that helps promote these crops to the concerned authorities in several governorates (Ramallah, Nablus, and Salfit). This was achieved by considering the agro-dealers, agro-industrialization, and extension workers' perspectives in relation to the variable of gender, business, academic qualifications, and practical experience. To realize the objectives of the study, the researchers prepared and developed a final draft questionnaire consisting of 46 items, applied on a sample of 35 stakeholders in Ramallah and Al-Bireh, Nablus, and Salfit governorates, selected via the available method. The questionnaire enjoyed a high degree of credibility and reliability, as the reliability coefficient reached a value of 0.82 on the Cronbach alpha scale. The data were collected, classified, analyzed, and interpreted to reach the desired results. The results showed that the role of the MISF in improving the performance of agricultural marketing, product management, and the agri-food supply chain is beneficial to the marketing groups in the form of partnership.

The study results revealed that MISF would provide a computerized information system used to collect, analyze, and disseminate information on agricultural production, prices, and other information related to farmers, traders, manufacturers, and others involved in dealing with agricultural products. It will also help address some of the problems facing the farmers' markets. The researchers undertook a new approach that makes both farmers and buyers responsible for uploading their agricultural products and price information via the Internet and mobile data availability. The system will facilitate trade by providing options for sellers to communicate with buyers. This system will provide information on needed agricultural products by analyzing consumer consumption and market trends.

In light of the findings of this study, the researchers concluded a set of recommendations, including: Consolidating the relationship between the Ministry of Agriculture with the farmers and traders, increasing the number of scientific research that deals with and is interested in market information systems as there were very few researches conducted on this topic, and providing the infrastructure for the central markets.

THE STUDY PROBLEM AND QUESTION

The Palestinian government worked to establish a new institutional phase in building the Palestinian ministries and institutions on professional grounds, relying on employing information technology systems in various sectors in Palestine.

The Ministry of Higher Education, in 2019, launched an initiative to support implementing research projects in various sectors in Palestine. In light of the Palestinian government's increasing interest to employ technology in relation to improving the quality of services provided to farmers and citizens, approval for this project was granted. This project aims at realizing ambitions in building electronic markets that serve the beneficiaries of agricultural production from the citizen to the farmers and commercial markets, in addition to the industrial production sector to transform into e-government at the national level, which allows the citizen to obtain various services remotely, regardless of location. The project contributes to improving the performance, quality of services and enhancing the beneficiaries' revenues from the agricultural sector. Based on this approach, the researchers will try to elucidate the research problem by answering the following questions:

1. Are there statistically significant differences at the level of significance $\alpha \leq 0.05$ in the role of MISF in improving the agricultural marketing performance from the farmers' and extension workers' viewpoint, attributed to the variables of gender, years of working experience, educational qualification, years of work in the market, and the business field?
2. What are the problems that may arise when developing and programming MISF?
3. How can these problems be addressed by developing web and mobile applications?
4. What are the problems and limitations that arise with the use of the MISF?
5. Do the study sample responses differ from the problems facing MISF according to the different variables of gender, academic

qualification, years of work in the market, and the business sector?

Study Hypotheses

This study relied on a set of hypotheses that aim to address the problems of the study and achieve its objectives, as follows:

1. There are no statistically significant differences at the level of significance a ≤0.05 in the role of MISF in improving the performance of agricultural marketing from the viewpoint of the farmers, agricultural extension agents, and traders due to the variables of gender, years of working experience, and educational qualification.
2. There are no statistically significant differences at the level of significance a ≤0.05 in the role of MISF in improving the performance of agricultural marketing from the viewpoint of the farmers, agricultural extension agents, and traders due to the variables of educational qualification, years of work in the market, and business sector.

Study Importance

The study's importance lies in the establishment of the electronic network for agricultural marketing to create a pioneering content for the use of information systems and smartphone applications to develop an electronic market for agricultural crops in Palestine. It will gain such importance by being one of the first studies to analyze mobile information systems' uses in promoting agricultural products through the smart application of information systems.

The importance of this study from the theoretical and practical sides lies in the following aspects:

1. Providing information about the required agricultural products by analyzing consumer consumption and market trends using data mining techniques.
2. A stable supply and demand relationship will prevent the decline in agricultural product prices and help stabilize market prices. The market information system will play an important role in industrial manufacturing and food supply chains.
3. The system will facilitate the marketing of agricultural products by providing sellers with capabilities to communicate with buyers. The system will provide information on needed agricultural products by analyzing consumer consumption and market trends.

Study Objectives

The study aims to identify the uses of information systems in web applications and smart mobile devices in agricultural crop supply chains in Palestine through a case study of the smart network for agricultural marketing aimed at directly linking the community of small farmers in their markets. Among the other objectives of the study is to conduct an analysis of the strengths, weaknesses, opportunities, and threats of implementing the smart system as one of the agricultural information systems, to reach improvements in the performance of the current application and make room for other applications that contribute effectively to the transition in agricultural marketing from traditional to modern approaches.

The main objectives of the study can be summarized as follows:

1. To identify the role of MISF using web-based applications and mobile smartphones in regulating the flow of agricultural products and finding optimal ways to distribute agricultural productions and assist farmers.
2. To employ technology to promote the local agricultural system and improve productivity for those working in the agricultural value chain, including small farmers' businesses.
3. To improve the livelihoods of farmers in Palestine.
4. To reach new markets, value chains, and business models.
5. To reinforce the relationship between farmers and consumers in the most potent way.
6. To identify the main problems of implement MISF.

Study Limitations

The study comprised the following limitations:

- Spatial limitation: This study was conducted on a sample of local community institutions in Nablus, Salfit, and Ramallah governorates.
- Time limitation: The study was conducted between 9/2019-2/2020.

- Human limitation: The study population solely included extension agents, farmers, traders, and factories.

Study Approach and Process

In this study, the Quasi-experimental and analytical approaches to the data were adopted. The system needs to program and examine the outputs, compare them with the results to include modifications to the inputs, and observe the desired results to harmonize them with the study's nature. This approach enhanced the understanding of the problem, identified the study variables to design the questionnaire, and formulated the study problem and questions. After completing the questionnaire, which includes the study sample, data analysis was conducted using SPSS to reach the needed statistics and results.

LITERATURE REREVIEW

Arabic Studies

The study of **Marzin J. et al. (2019)** showed the reality and problems of agricultural marketing in the Palestinian Territories (PT). The study focused on the impact of the Israeli measures on this sector, as it considered the agricultural sector the most prominent victim of Israeli economic policies. The study clarified the Israeli impediments to exporting through Israeli crossings, ports, and airports, as well as the Israeli restrictions to Palestinian agricultural marketing, which greatly limited its development. The study also addressed the absence of governmental marketing sovereignty.

Hrimat and Isaac, (2017) conducted a study that reviewed some of the obstacles that obstructed marketing services in the OPT. The study divided these obstacles into obstacles related to production and market requirements and obstacles related to marketing services and export. Concerning the production constraints and market requirements, the study indicated that the Palestinian agricultural production had undergone remarkable changes due to changes in the traditional Arab consumers' tastes, as each agricultural pattern attempts to respond to the specific environmental conditions, marketing, and planning processes, which thus prevent laying the foundations for successful marketing alternatives. As for the obstacles related to marketing services, quality requirements, and specifications, the study refers to the sensitive nature of the vegetable and fruit trade in light of the difficult Israeli procedures, the weak application of the standards and quality system on exported agricultural products, the lack of refrigerated transport means for transporting the agricultural products, and the lack of supporting marketing service facilities (Monitor 2020a).

FAO (2013) conducted a study that highlighted the problems and obstacles facing agricultural marketing in Palestine. These problems included Israeli practices, in addition to the technical and institutional obstacles. The study put forth some appropriate marketing strategies and proposals for the advancement of the agricultural sector, some technical and production proposals, other proposals for institutional building, finally, proposals for the role of the government and the private sector, whether in the scope of local marketing or external marketing. Specifically, the proposals included: Establishing an efficient marketing information system, improving quality specifications for agricultural production, conducting the necessary studies related to agricultural production costs, participating in holding local and international exhibitions, examining all systems and instructions set by importing agencies for agricultural production, and following up on the changes that occur to them, and working to reduce high production costs relatively speaking in Palestine, in order to maximize the competitive advantage of the Palestinian production and maximize efforts towards high-value crops in international markets (Monitor 2020b).

Srouji (2009) conducted a study that reviews the local marketing of irrigated cash crops in Palestine. The importance of this study lies in its targeting of the farmers who are usually considered among the most vulnerable groups of society due to their exposure to risks. The study also focuses on the problems they suffer from, taking into account the farmers' views in solving these problems, by distributing a special questionnaire to farmers.

The study also clarified that other groups, other than farmers, such as mediators, could benefit from the final consumer and the government. Regarding the mediators, the researcher interviewed a number of them to find out the problems that the Palestinian agricultural

marketing sector suffers from. In terms of the consumer, a mediator can benefit by reducing the marketing cost, which leads to lower prices at the retail level.

Foreign Studies

As for foreign studies, the current study referred to the following:

(Nisansala, 2019), FAO (2017) and (COMCEC, 2018), in their review, present background introduction, theories, literature review, and analysis of information systems in agriculture.

Studies conducted by different teams of researchers, such as Shepherd (2011), and David-Benz et al. (2011; 2016), indicated that the first-generation market information systems were mostly based on a single model, regardless of the market being studied, the type of product, and the country. Other systems often focused exclusively on price information, relied on project-based financing, and were imperatively implemented by public bodies, such as marketing boards and ministries (Rubio, 2020), (Nwafor et al. 2020), (Muto, 2009), (Aker, 2010), (Belakeri et al. 2017), (Chikuni et al. 2019), (Roslin et al. 2020), and (Ezinne et al. 2020).

Several studies by David-Benz et al. (2011; 2012), (Galtier, 2014), and Mukhebi and Kundu (2014), showed the importance of the spread of mobile phones and the Internet, which paved the way to the rise of a new generation of Management Information Systems (MIS). The Information and Communications Technology (ICT) sector developments have made it possible to minimize the lag in transferring price data from collection points to Central Processing Units (CPUs) and disseminating information to the intended recipients. MIS that uses ICT has become known as the "second generation" MIS, or the 2GMIS "Second Generation of Management Information Systems".

Several studies were conducted on MIS all over the world; among the most important of these studies are Mendoza (2006) and MIOA (2006), David-Benz et al. (2016), and Zoltner and Steffen (2012). Although some of these studies are now considered out of date, they still provide useful information and practical indications for those who wish to create new MIS or improve existing ones.

ICT presents unprecedented opportunities to empower smallholder farmers by strengthening their capabilities in marketing their products (Langat et al. 2016), (Rubio et al. 2020), and (Nisansala, 2019).

In the agricultural industry, Artificial Intelligence (AI) and Data Mining (Abuzir, 2018) are expected to report significant growth in the near future. Farmers can track their livestock in real-time by making use of AI. Dairy farms can now individually monitor the behavioral aspects of animals with AI solutions, including picture classification with body condition score and feeding patterns and facial recognition for livestock. Furthermore, farmers use machine vision that allows them to identify facial features (Global, 2020).

Study Tool

The researchers developed a study tool (questionnaire) for the purpose of gathering information to answer the study's questions and hypotheses after reviewing a number of previous studies related to the reality of sales markets and market information systems. The tool, in its final form, consisted of two parts:

First: Initial information related to local community institutions' managers such as:

1. Gender: Male and female.
2. Educational Level: High school, diploma, B.A., M.A., and more.
3. Years of your work in the market: 5 years or less, 5 years to less than 10 years, 10 years and more.
4. The business sector you work in: Industrial sector, commercial sector, agricultural sector, and the service sector.

Second: A questionnaire about the role of market information systems for Palestinian farmers. The questionnaire was designed based on the five-dimensional Likert scale where items were constructed in a positive direction and weights were given, as shown in Table 4.

After the data collection process, the questionnaires were coded and entered into the computer, using the statistical packages program (SPSS) to process the data, extract the results, answer the study questions and test its hypotheses. The following statistical processes were used:

- Likert scale to measure the degree of importance and the role of market information systems for Palestinian farmers.
- Frequencies and percentages to identify the study sample distributions.
- Descriptive statistics to answer the study questions.
- Cronbach's alpha to measure the degree of reliability of the study scale.
- Pearson correlation coefficient to measure the degree of consistency in the study scale.
- Independent sample t-test, to test the significance of the differences between the study sample members in reference to the variables that contain two independent samples, such as gender.
- One-way ANOVA test, to test the significance of the mean differences between the study sample.

To measure the responses of the sample members to the study items, a Likert scale was used, as shown in Table 1.

In order to determine the degree of approval (scale of correction), five levels were defined, as in Table 2.

It was obtained using the range for the scale options, which is the upper class of the scale-the lower class 5-1= 4, and to extract the length of the average category, the range was divided by the upper class of the scale, i.e., 5÷4=0.8, which is the length of the mean category.

Tool Validity

The validity of the tool was verified. It was presented to a peer-reviewers group who suggested the need to make some amendments to its items. The number of items of the questionnaire, which represented the overall field of research, reached 46 items in its final form.

Table 1 Likert 5th Scale

Response	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Degree	5	4	3	2	1

Table 2 :Correction Scale Levels for the Study Scale

Arithmetic Mean Category*	Approval Category	Approval Percentage	Approval Degree
1-1.8	Strongly disagree	36 % and less	Very low
1.81-2.6	Disagree	36.1% - 52.9%	Low
2.61-3.4	Neutral	53% - 68.9%	Moderate
3.41-4.2	Agree	69% - 84.9%	High
4.21-5	Strongly agree	85% -100%	Very high

Tool Reliability

The reliability of the statistical tool for the items was verified using the Cronbach alpha test. The reliability of the study tool reached 82.4%, which is the appropriate stability factor that meets the purpose of the study.

Statistical Processing

SPSS was employed to process the following statistics:

7. Arithmetic means
8. T-test for independent samples
9. One way analysis of variance
10. The Cronbach alpha equation to measure reliability
11. Scientific results

Reliability scale of the study tool: It is used to give the scale the same results if re-applied to the same sample under the same conditions. The tool was measured using Cronbach's alpha stability coefficient. The stability factor was calculated using the SPSS program, through which the discrimination coefficient is calculated for each question, and omit the question of which discrimination coefficient is weak or negative. The following are the results of the Cronbach alpha test for the scale, as they appear in Table 3.

Table 3 Results of the Cronbach Alpha Test to Examine the Internal Consistency of the Scale used in the Study.

Scale	No. of Items	Cronbach's Alpha
Total score of the scale	46	82.4

It is noted from the results in Table 1 that the value of the reliability coefficient for the study scale was high and reached 82.4%, which indicates good consistency and stability between the items of the scale used in the data collection tool.

Validity scale of the internal consistency of the study tool: The internal consistency of the questionnaire questions means the strength of the correlation between the scores of each scale and the degrees of the overall questionnaire represented in the scale axes, as shown in Table 4.
*The correlation coefficients in Table 4 are considered statistically significant internal stability coefficients at a significant level of 0.05.
** The correlation coefficients in Table 4 are considered as statistically significant internal

consıstency coefficients at a significant level of 0.01.

Table 4: The Results of the Pearson Correlation Test to Examine the Validity of the Internal Consistency Between the Items of the Questionnaire.

Axis	No. of Views	Total scale Pearson Correlation Coefficient	Significance Level
The reality of sales markets in Palestine	35	0.344*	0.043
Difficulties and problems facing the distribution systems currently in effect	35	0.091	0.602
The market information system role in achieving an efficient system	35	0.919**	0.000
Availability of technological requirements for market information systems	35	0.702**	0.000

It appears from the results in Table 4 that the value of the Pearson correlation coefficient between the total score of the study scale and the first axis was sıgnıficant, and the correlation was significant and moderate. In contrast, the value of the Pearson correlation coefficient between the total score of the study scale and the second axis was non-significant, and the correlation was non-significant and very weak. Whereas, the division of Pearson's coefficient between the total score of the scale and each of the third and fourth axes was statistically significant, and the correlation is strong (significant correlation at a significant scale of 0.01), which indicates a high consistency between the items of the scale used in the data collection tool.

Study methodology: The researchers used the experimental as well as the descriptive approach due to its relevance to the nature of this study. The survey was conducted on farmers, traders, factories, extension agents, and local community institutions and their relationship to some demographic variables.

Study population and sample: The study population consisted of farmers, merchants, extension workers, and factories in the governorates of Nablus, Ramallah and Al-Bireh, and Salfit. The researchers selected 50 of them using the available method as a sample to represent the study community. Table 5 shows the distribution of the study sample according to the study variables.

The features of the study sample:

The distribution of the study sample was done according to the qualitative variables in the questionnaire: Gender, academic qualification, years of work in the market, the business sector in which you work, as shown in Table 5.

It is evident from the results in Table 5 that the study sample consisted mostly of males at 85.7%, as well as holders of high school and bachelor's degrees at 37.1% each. Moreover, the majority of the sample had 10 years of working experience or more, at 48.6%. In addition, the majority of the sample members worked in the agricultural sector at 62.9%.

Table 5: The Proportional Distribution of the Study Sample According to the Demographic Variables

Independent Variables	Variable Levels	Repetition (#)	Percent (%)
Gender	Male	30	85.7
	Female	5	14.3
	Total	**35**	**100.0**
Educational Level	High school	13	37.1
	Diploma	7	20.0
	BA.	13	37.1
	MA. & higher	2	5.7
	Total	**35**	**100.0**
Years of working experience	Less than 5 years	6	17.1
	5-10 years	12	34.3
	More than 10years	17	48.6
	Total	**35**	**100.0**
The business sector in which you work	Industrial sector	1	2.9
	Commercial sector	9	25.7
	Agricultural sector	22	62.9
	Service sector	3	8.6
	Total	**35**	**100.0**

Results Related to the Research Questions

In this section, we will answer the research questions by conducting appropriate analysis and tests to each question separately, as follows:

The first sub-question: What is the reality of the markets in Palestine?

In order to explain the scores of the items of the first core area of the study's scale, the means, and standard deviations were calculated for each item, which answers the first sub-question, as shown in Table 6.

Table 6 Means, Standard Deviations, Percentages, and Ratings of the Study Sample' Responses to the Core Area of the Reality of the Markets in Palestine

Order	Item	Mean	SD	Percent %	Level of Agreement	Attitude
1	Lack of purchasing power among citizens due to hard economic conditions.	4.17	.891	83.4	1	High
2	Availability of Israeli products in the central markets in large quantities and at low prices.	3.94	1.305	78.9	4	High
3	Availability of a sufficient number of highly skilled labor in the central market.	3.17	1.124	63.4	5	Medium
4	Availability of a mechanism for selling damaged products in the market.	2.43	1.065	48.6	9	Low
5	The fluctuation of the quantities available in the markets due to the lack of coordination between farmers in the planting dates.	3.97	.954	79.4	3	High
6	The local bodies that oversee the markets are effective and efficient.	2.17	.985	43.4	12	Low
7	The lack of price control in the central market.	4.03	.954	80.6	2	High
8	The lack of corruption, bribery, mediation and favoritism.	2.40	1.397	48.0	10	Low
9	Availability of unified and integrated laws and legislations for collecting fees.	2.60	1.090	52.0	8	Low
10	Availability of electronic systems that record the quantities entering the market.	2.83	1.071	56.6	7	Medium
11	Availability of an effective market management system.	2.26	1.245	45.1	11	Low
12	Lack of infrastructure in most central markets.	2.89	1.207	57.7	6	Medium
	Total Score of the Third Core Area	**3.0714**	**0.37440**	**61.4%**	**---**	**Medium**

The overall agreement score for the first core area was 61.4%, which is a moderate degree of satisfaction with the reality of the markets in Palestine. The highest level of agreement was for item No.1, the lack of purchasing power among citizens due to hard economic conditions, at 83.4% with a mean of 4.17, which is the highest among all other means of the reality of markets in Palestine. Item No. 6, the local bodies that supervise the markets are effective and efficient, scored the lowest level of agreement at 43.4%, with a mean of 2.17, which is the lowest value for the first core area.

The second sub-question: What are the levels of difficulties and problems facing the current distribution system?

To identify the level of the difficulties, the means and the standard deviations were calculated for each item in the core area: Difficulties and problems facing the current distribution system, which answers the second sub-question, as shown in Table 7.

Table 7 Means, Standard Deviations, Percentages, and Ratings of the Study Sample's Responses to the Core Area of the Difficulties and Problems Facing the Current Distribution System.

Order	Item	Mean	SD	Percent %	Level of Agreement	Attitude
1	Inefficient road networks that connect between production areas and markets as well as export outlets.	4.29	.572	85.7	1	Very High
2	Lack of incentives for the workers in the field of distribution.	4.17	.618	83.4	2	High
3	Lack of land and maritime transportation and distribution companies specialized in marketing and exporting agricultural products.	3.83	.954	76.6	7	High
4	The ongoing Israeli closures and barriers, which impact the availability of products in the central markets	3.86	1.004	77.1	6	High
5	Poor distribution and absorption capacities, as well as the high cost of the transportation process.	3.97	.822	79.4	5	High
6	Randomness in the distribution system and the lack of clear references in the Palestinian Territories.	4.11	1.078	82.3	3	High
7	Isolation of many areas due to the construction of the apartheid wall.	3.69	1.207	73.7	8	High
8	The lack of agreements that protect the Palestinian trader from fraud, in case he/she exports agricultural products.	3.97	1.043	79.4	4	High
9	The transport and communication sector is well developed.	2.37	1.114	47.4	10	Low
10	There are no logistical restrictions on exports to other countries.	2.60	1.265	52.0	9	Low
11	Administrative costs for import (insurance, transportation, freight, fees, etc.) are reasonable.	2.11	.758	42.3	12	Low
12	There is no complexity in the process and requirements for importing from other countries.	2.17	.891	43.4	11	Low
Total Score of the Third Core Area		3.4286	0.36444	68.6%	---	Medium

The overall agreement score for the second core area was 68.6%, which is a moderate degree of satisfaction with the difficulties and problems facing the current distribution system. The highest

level of agreement was for item No.1, weakness of the road network linking production areas with markets and export outlets, at 85.7%, with a mean of 4.29, which is the highest among all other means of this core area. Item No. 11, administrative costs for import (insurance, transportation, freight, fees, etc.) are reasonable, scored the lowest level of agreement at 42.3%, with a mean of 2.11, which is the lowest value in the second core area.

The third sub-question: To what extent does the market information system contribute to achieving an efficient system?

Table 8 Means, Standard Deviations, Percentages, and Ratings of the Study Sample's Responses to the Core Area of Contribution of the Market Information System Towards Achieving an Efficient System

Order	Item	Mean	SD	Percent %	Level of Agreement	Attitude
1	The ability to have a direct access between farmers and their markets.	4.09	1.040	81.7	3	High
2	The ability to extract a wide range of information in a quick and automatic manner.	4.09	1.095	81.7	4	High
3	Availability of modern and effective marketing techniques that achieve sustainable development.	4.09	.951	81.7	5	High
4	Availability of an integrated mobile application for the agricultural sector.	3.77	1.239	75.4	11	High
5	Availability of an e-market for buying and selling agricultural products and agricultural production supplies.	3.63	1.374	72.6	15	High
6	The ability to update the farmer's data periodically.	3.71	1.100	74.3	12	High
7	The ability to publish all details of demand and supply.	3.91	.919	78.3	7	High
8	Communication between the seller and the buyer is established through SMS.	3.89	1.157	77.7	8	High
9	The information can be modified easily through the computer system.	3.71	1.152	74.3	13	High
10	The ability to provide contact information of subscribers upon request.	3.71	1.226	74.3	14	High
11	Agricultural crop prices are sent via text messages according to their importance.	3.83	1.150	76.6	9	High
12	The ability to provide crop price analysis for the last three years, including high and low prices.	4.09	1.040	81.7	6	High
13	Availability of an efficient system to enhance planning for the agricultural cycle.	3.80	.994	76.0	10	High
14	The ability to improve the quantity, quality and safety of agricultural products as well as follow up on the wholesale prices daily.	4.11	.867	82.3	2	High
15	The ability to promote efficient agricultural transactions and contact agricultural supplies' companies.	4.20	.964	84.0	1	High
	Total Score of the Third Core Area	**3.9086**	**.77427**	**78.2%**	**---**	**High**

The overall agreement score for the third core area was 78.2%, which is a high degree of satisfaction with the contribution of the market information system towards achieving an efficient system. The highest level of agreement was for item No.15, the ability to promote efficient agricultural transactions and contact agricultural supplies' companies, at 84.0%, with a mean of 4.20, which is the highest among all other means of this core area. Item No. 5, availability of an e-market for buying and selling agricultural products and agricultural production supplies, had the lowest level of agreement at 72.6%, with a mean of 3.63, which is the lowest value in the third core area.

The fourth sub-question: To what extent are the technological requirements available for the market information system?

Table 9 Means, Standard Deviations, Percentages, and Ratings of the study sample's Responses to the Core Area of the Extent of the Availability of Technological Requirements for the Market Information System

Order	Item	Mean	SD	Percent %	Level of Agreement	Attitude
1	Availability of a comprehensive and adequate database.	4.17	.785	83.4	3	High
2	Availability of advanced hardware and software to obtain information quickly.	3.94	.968	78.9	6	High
3	Ability to train workers on the use of special devices and software.	4.11	.932	82.3	4	High
4	Availability of a constant access to the internet at high speed and large capacity to learn about latest developments and products.	4.29	.987	85.7	1	High
5	Availability of a sufficient number of working programmers.	3.86	1.033	77.1	7	High
6	Availability of advanced competencies and skills	4.23	.731	84.6	2	High
7	Availability of an efficient and safe system.	4.09	.818	81.7	5	High
	Total Score of the Third Core Area	**4.0980**	**.69622**	**82.0**	**---**	**High**

The overall agreement score for the fourth core area was 82.0%, which is a high degree of agreement with the extent of the availability of the technological requirements for the market

information system. The highest level of agreement was for item No.4, availability of constant access to the internet at high speed and large capacity to learn about the latest developments and products, at 85.7%, with a mean of 4.29, which is the highest among all other means of this core area. Item No. 5, availability of a sufficient number of working programmers, had the lowest level of agreement at 77.1%, with a mean of 3.86, which is the lowest value in the fourth core area.

The fifth sub-question: Are there statistically significant differences in the respondents' opinions about the role of the market information system for farmers due to different variables: Gender, academic qualification, years of working experience in the market, and business sector?

To answer this question, we will conduct tests for each demographic variable separately to identify the presence of statistically significant differences in the opinions of the respondents on the role of market information system for farmers, as follows:

Gender variable:

In order to examine the presence of significant differences in the respondents' opinions about the role of the market information system for farmers due to the variable of gender, a T-test was performed for two independent samples, as shown in Table 10.

Table 10: The T-test for Two Independent Samples to Identify the Differences in the Respondents' Opinions about the Role of the MISF Due to the Variable of Gender

Gender	Descriptive Statistics			T-test		
	Number	Mean	Standard Deviation	T - value	Degree of Freedom	Sig.
Male	30	3.6036	0.35251	0.404	33	0.689
Female	5	3.5348	0.35675			

It appears from the results in Table 10 that the level of significance for both genders is 0.689, which is higher than $\alpha \leq 0.05$, after dividing it by two, because the test was conducted for both genders. Consequently, there were no statistically significant differences in the opinions of the study sample (respondents) on the role of MISF due to gender, meaning that the opinions of both are equal on average. There is no statistical value for the small differences in their averages.

Variables of academic qualification, years of working experience, and business sector:

In order to examine the significant differences in the respondents' opinions on the role of MISF due to the variables of academic qualification, years of working experience, and business sector, the one-way ANOVA test was conducted. The results of the test are shown in table 11.

Table 11: Results of the One-way ANOVA Test to Examine the Significance of the Differences in the Averages of the Sample's Responses on the Role of MISF Due to the Variables of Academic Qualification, Years of Working Experience, and Business Sector

Variable	Variance Source	Degree of Freedom	F-test	Sig.
Educational Level	Between Groups	3	1.022	.396
	Within Groups	31		
	Total	**34**		
Years of Working Experience	Between Groups	2	.301	.742
	Within Groups	32		
	Total	**34**		
Business Sector	Between Groups	3	1.755	.176

The results in Table 11 showed that the F test's level of significance for the variance analysis of the academic qualification variable was 0.396, which is higher than $\alpha \leq 0.05$. Based on this, we conclude that there were no statistically significant differences in the study sample (respondents) opinions on the role of MISF due to the academic qualification variable. This means that the respondents' opinions of all academic qualifications are equal on average, and there is no statistical value for the small differences in their averages.

The results in Table 11 also showed that the F test's level of significance for the variance analysis of the years of working experience variable was 0.742, which is higher than $\alpha \leq 0.05$. Based on this, we conclude that there were no statistically significant differences in the opinions of the study sample (respondents) on the role of MISF due to the years of working experience variable. This means that all opinions of the respondents who have different experiences are equal on average, and there is no statistical value for the small differences in their averages.

The results in Table 11 showed that the F test's level of significance for the variance analysis of the business sector variable was 0.176, which is higher than $\alpha \leq 0.05$. Based on this, we conclude that there were no statistically significant differences in the study sample (respondents)

opinions on the role of MISF due to the business sector variable. This means that all opinions of the respondents of the different business sectors are equal on average, and there is no statistical value for the small differences in their averages.

From the above results, there is a consensus that there is a role for MISF, as the demographic variables did not show any differences in the respondents' views on this matter. Consequently, we can now answer the study's main question: What is the role of MISF?

The previous analysis of the answers to the sub-questions shows that there is a role for MISF. The study scale results show a medium to a high degree of agreement on the existence of a role for MISF.

The Proposed System: MISF

The advance of information and communication technologies (ICTs) for development in Palestine and especially the availability of mobile data will mark the importance of providing information for the agricultural sector.

Farmers need to be empowered to allocate the scarce resources of the farms. Accordingly, the researchers will select different West Bank farmers as a case-study to apply a system analysis. The farm case study helps identify and analyze relevant material and information flows, production processes, and their interconnections and synergies.

Market Information Systems for Farmers (MISF) is a computerized information system used to gather, analyze, and disseminate information about agricultural yields, prices, and other information relevant to farmers, traders, manufacturers, and others involved in handling agricultural products.

In this study, we will try to address some of the problems facing the farmers' markets. We will develop a new approach that will enable farmers and buyers to take responsibility for uploading their agricultural products and price information via the internet and 3G technologies.

The system will facilitate trade by creating a capacity for sellers to contact individual buyers. This system will provide information on what agricultural products are in demand by analyzing consumer consumption and market trends.

The system will collect demographic details such as the types of crops grown, production size, prices, and cost and may provide access to the types of irrigation, soil and fertilizers as inputs from the farmers as well as other information on product consumption. The system will also advise farmers and find ways to help them lower costs and improve productivity using data mining techniques.

In general, the system will track farmers' businesses and provide ongoing support in areas such as labor, costs, yields management, product consumption, harvest management, market price discovery, and strong relation with buyers.

MISF was designed to target different users. Users create an account and select its type from a list managed by the system administrator, as in Figure 1.

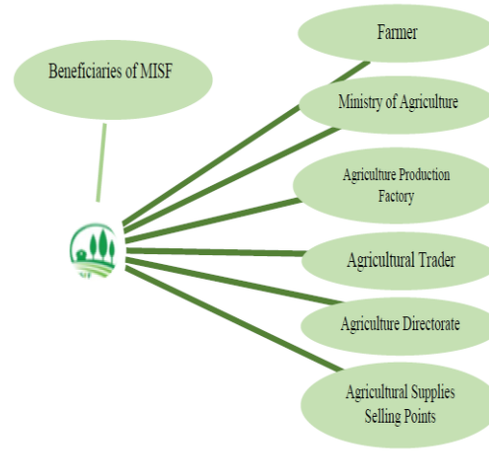

Figure 1. Users of MISF

The computerized system was developed and designed to be comprehensive to serve all sectors of agriculture in the governorates. The computerized agricultural system consists of two parts:

- The first part is the homepage of the system. It is accessed by the visitors through the website and the mobile application, as shown in Figure 2.
- The second part consists of a control panel secured with a username and password to set and manage the system's settings.

Figure 2. The homepage of the system

The system was developed for the different stakeholders, for the farmer, agricultural trader, agriculture production factory, Ministry of Agriculture, agriculture directorate, and agricultural supplies selling points. The system is accessible through smartphones and computers.

The following is a brief on how each user can utilize the system:

- System management: Through an account, the system can be managed by adding the system's constants, such as the names of crops and equipment. Moreover, the administrator can modify the status of the accounts and allow or block some accounts. The Ministry of Agriculture can be the administrator of the system.
- Farmers: The farmer can list his/her assets from agricultural lands, types of crops, dates of harvest, and operational expenses, to help with the pricing process.
- Agricultural facility: The agricultural trader can create orders on products through the system and be familiar with the current supply of agricultural products in the market and the location of certain products, as well as their marketing due date.
- Agricultural supplies selling points: These selling points can add, through the system, what they have available from agricultural equipment and supplies, such as fertilizers.
- Agriculture directorates: The directorates of agriculture in the governorates can communicate with farmers, merchants, and agricultural factories to provide assistance and guidance on agricultural work.

Stages of development

The system was developed based on the stages of computer systems' methods and design. The Object-Oriented Development Approach was adopted for developing the system. In this approach, the users of the system identified as "Actors" and the different functions for each user as "use cases". The system's input and output screens were designed and linked to the databases. The steps for developing the system can be summarized as follows:

- Databases of the agricultural system consisted of accounts tables, their types, Palestinian cities, communities, and more.
- The Palestinian cities and towns data were listed in a table to serve the agricultural system and the dimensions of the communities, which were also listed in electronic maps, accessed by the mobile application and, if necessary, by the computer.
- The types of accounts that use the dynamic control panel were included. The system administrator can add new types when necessary, as in Figure 3.

Figure 3. The page for managing accounts.

- Implementing security and protection options in the system to protect the system, secure access to the system and its data, identify the malicious use of the system, and the ability to delete or suspend his account.
- Privacy - building the system in such a way that preserves privacy for all system users by protecting their menus, privileges, and accessing their data. Prevent other system users or the system administrator from accessing their screens and data too.

The software application on smart devices allows the system user to manage all the different operations, such as following up orders and adding the number and quantity of crops from his account.

In this way, the merchant can search for and order agricultural products (Figure 4).

Figure 4. The page to list the available agricultural products and add a new gallery

DISCUSSION

Based on the selected data from the questionnaire and the statistical method analysis, first, we developed a general discussion of the results to answer the study's main question: What is the role of MISF? The analysis of the data in this study shows that there is a role for MISF. Later, we developed our MISF that suits the different stakeholders' needs, including an easy adaptation, user-friendliness, and accuracy in depicting the various production processes, management, and services.

The most important findings of the study are:

- The overall degree of agreement for the core area of the reality of markets in Palestine was medium, which indicates a moderate degree of satisfaction. This shows the sample's desire to develop these markets.
- The overall degree of agreement for the core area of difficulties and problems facing the current distribution system was medium, which indicates a moderate degree of satisfaction. This shows the sample's recognition of the presence of problems in these markets and the need to solve them.
- The overall degree of agreement for the core area of the market information system's contribution to achieving an efficient system was high, which indicates a high degree of agreement on its status.
- The overall degree of agreement for the core area of the extent of the availability of the technological requirements for market information system was high, which indicates a high degree of agreement on this core area, and that the technological environment is available and can be invested in developing effective information systems.
- There were no statistically significant differences in the study sample's opinions (respondents) on the role of MISF due to gender. This means that both respondents' gender opinions are equal on average, and there is no statistical value for the small differences in their averages.
- There were no statistically significant differences in the study sample's opinions (respondents) on the role of MISF due to the academic qualification variable. This means that the opinions of the respondents of all academic qualifications are equal on average, and there is no statistical value for the small differences in their averages.
- There were no statistically significant differences in the study sample's opinions (respondents) on the role of MISF due to the years of working experience variable. This means that all opinions of the respondents who have different experiences are equal on average, and there is no statistical value for the small differences in their averages.
- There were no statistically significant differences in the study sample's opinions (respondents) on the role of MISF due to the

business sector variable. This means that all the opinions of the respondents of different business sectors are equal on average, and there is no statistical value for the small differences in their averages.
- There is a role for MIF, as the study results showed a medium to a high degree of agreement on it.

The scientific discussion of the results is carried out in light of the objectives of this study and the results of the previous studies in the field of research, as well as after considering what was accomplished from the required tasks for this research.

Challenges

Today, information technology and communication reshaped agricultural production management, process, and services and is entering a new era where computerized systems can support farmer's decisions to help them in their daily activities. These systems can work on simple record-keeping software or/and complex systems that can manipulate large amounts of data and provide decision support capabilities using artificial intelligence and data mining. In this paper, the development of MISF utilizes different technologies, such as web technology, smart devices, 3G, and Internet technology.

The main focus of MISF is to perform farm activities based on all farm transactions. Different users or stakeholders in the agricultural sectors can use the system. The application was successfully implemented using web technology and smart devices and tested where all different scenarios were recorded.

However, when it comes to programming the application, many issues may be considered to depict all processes accurately. This statement holds, in particular, true for our MISF with the following concerns or challenges:
- When we programmed the system, we encountered several problems, including technical problems, when writing the source code.
- Writing the source code took a long time because it needed to be tested by all users.
- The process of collecting data and distributing the questionnaire to farmers and traders took much time because they did not send them back on time.
- The process of documenting, analyzing, and discussing the questionnaires' responses took a long time.
- The lack of the already-agreed-upon equipment that was to be used during the project by relevant parties.
- The lack of a database for central markets, and this required time in order to introduce the agricultural crops and their quantities.
- The randomness of the commercial markets.
- Most workers in markets need to be instructed and trained to use such systems.

CONCLUSIONS AND RECOMMENDATIONS

The following section summarized the main finding, conclusions, and recommendations based on the analysis of the data and interviews with the different groups.

Findings
- Developing a computerized market information system for the benefit and use of the concerned parties.
- Developing a mobile application for the market information system.
- Providing a database on agricultural crops, their prices, quantities, and orders for the benefit and use of the concerned parties.
- Establishing an electronic equipped lab for interested researchers in the field of Internet of Things (IoT) for scientific research purposes.
- Establishing a control system for crops and quantities offered in the local market by the Ministry of National Economy and the Ministry of Agriculture.
- Saving cost, time, and effort through the use of a mobile application, as the farmer and trader can compare agricultural crops and the available quantities online.
- Digitizing and organizing all operations in the central markets to achieve transparency.

Recommendations

The study concluded a number of recommendations as follows:
1. Consolidating the relations between the Ministry of Agriculture and farmers, traders as well as the Ministry of National Economy,

to place all its capabilities and facilities at the service of the farmers.
2. Organizing seminars and distributing awareness leaflets on the market information system's role in improving the performance of the farmers' markets (Hisbah) in Palestine.
3. Focusing on qualitative scientific research that targets the needs and problems of farmers. This can be done by networking with research centers and institutions in the community and using the University's scientific research to solve these problems.
4. Organizing scientific conferences, workshops, and study days on serving farmers and their problems to propose appropriate solutions.
5. Controlling the number and specializations of workers inside the central markets.
6. Reconsidering the existing commercial markets infrastructure to make it compatible with the application of such systems.
7. Providing a database for available agricultural crops, the needed quantities, and the quantities of crops imported from inside the green line.
8. Establishing a clear mechanism for working and coordinating between all relevant parties with regard to marketing agricultural products, so it would be carried out in an organized and targeted way, as it is currently random.
9. Supporting the Palestinian farmer with modern agricultural means that keep pace with technological developments, especially in terms of insecticides and their controlled use under the Ministry of Agriculture's supervision.
10. Establishing a mechanism for the disposal of damaged goods retrieved from the central markets.
11. Implementing a mechanism for calculating commissions and monitoring the internal system used by markets for pricing products that enter the central market.

Conclusion

The study aimed to identify the role of MISF in order to establish and automate a system to improve the reality of markets and manage products and the agricultural food supply chain to benefit the marketing circles in partnership with the Ministry of Agriculture, the Central Statistics Department, and the Ministry of Higher Education and Scientific Research.

The study results revealed that MISF would provide a computerized information system used to collect, analyze, and disseminate information on agricultural production, prices, and other information related to farmers, traders, manufacturers, and others involved in dealing with agricultural products. It will also help address some of the problems facing the farmers' markets. The researchers undertook a new approach that makes both farmers and buyers responsible for uploading their agricultural products and price information via the Internet and mobile data availability. The system will facilitate trade by providing options for sellers to communicate with buyers. This system will provide information on needed agricultural products by analyzing consumer consumption and market trends.

Based on the study data and analysis, as well as the researchers' perspectives, it was concluded that ICT could play an important role in promoting and developing central markets in Palestine through organizing and saving time, effort, and money in all sectors. In light of this research's results, the researchers recommend that universities cooperate with the Ministry of Agriculture to support farmers and traders and provide an integrated information system to enhance the capacities and create a central system that serves the agricultural sector and the State. The researchers also recommend the need for holding workshops to raise awareness and enrich the knowledge of concerned parties (system users) on agricultural technologies, in addition to supporting them financially to use these technologies.

The researchers also recommend focusing on research that directly addresses the difficulties and problems facing Palestinian farmers in order to present appropriate solutions in cooperation with universities and research centers. Moreover, it is recommended to evaluate other successful market information technology applications in other countries and introduce good practices that help promote agriculture. The researchers believe that the system should be implemented and further developed to become an endorsed comprehensive system for the benefit of all.

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Generation of Multiple Frequency Pulse Width Modulation Signals Using FPGA

توليد إشارات تعديل عرض النبض متعددة الترددات باستخدام مصفوفات البوابة القابلة للبرمجة

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ABSTRACT

Microcontrollers, such as the one used in Arduino, are low-cost, simple, and suitable for low frequency and speed applications. However, concurrent processing and concurrent generation of multiple signals are necessary in many applications such as automotive sector, broadcasting, consumer electronics, and industrial applications. Field Programmable Gate Arrays (FPGAs) can generate concurrent signals that are more accurate than signals generated by microcontrollers. Moreover, FPGAs have higher performance than microcontrollers do mainly in the high frequency applications. In this paper, multiple frequency pulse width modulation (PWM) signals are concurrently generated from an FPGA Cyclone IV core board. The frequency of the generated PWM signals, the duty cycle, and the bit resolution are reconfigurable via simple variables in the entity section. The solution consists of six PWM signals. The generated signals are employed in three practical scenarios. In the first scenario, three of the produced signals are used to control light emitting diodes (LEDs) and generate music tones, and alarms. In the second scenario, one of the produced PWM signals is used to generate a sine wave, and then smoothed via an add-on filter, which makes the develop system to work as a function generator. In the third scenario, one of the produced PWM signals is used to control the speed of a motor by changing the duty cycle percentage. In this context, the developed system works as an analogue to digital converter (DAC) that is able to control analogue systems from a digital environment. The proposed system is compact, low-cost, scalable, and generates accurate signals.

Keywords: DAC, Motor Control, Duty Cycle, FPGA, LPF, PWM, Sine Wave Generation.

الملخص

تعتبر أجهزة التحكم الدقيقة، مثل تلك المستخدمة في متحكمات (Arduino)، منخفضة التكلفة وبسيطة، ومناسبة لتطبيقات السرعة والتردد المنخفض. ولكن، المعالجة المتزامنة والتوليد المتزامن لعدة إشارات ضروري في كثير من التطبيقات مثل قطاع السيارات، البثّ، إلكترونيات المستهلك، والتطبيقات الصناعية. يمكن لمصفوفات البوابة الميدانية القابلة للبرمجة (FPGAs) أن تنتج إشارات أكثر دقة من الإشارات التي يتم إنشاؤها بوساطة المتحكم الدقيق. علاوة على ذلك، تتمتع (FPGAs) بأداء أعلى من المتحكمات الدقيقة بشكل أساسي في التطبيقات عالية التردد. في هذا البحث، يتم إنشاء إشارات تعديل عرض النبضة متعددة الترددات (PWM) بشكل متزامن من اللوحة الأساسية (FPGA Cyclone IV). تردد إشارات (PWM) المتولدة، ودورة العمل، ودقة البت هي المتغيرات التي يمكن إعادة ضبطها من خلال متغيرات بسيطة في قسم الكيان (entity) يتكون الحل من ست إشارات (PWM). تم توظيف الإشارات التي أنتجت في ثلاثة سيناريوهات عملية. في السيناريو الأول، تم استخدام ثلاثة من إشارات (PWM) الناتجة للتحكم في الصمامات الثنائية الباعثة للضوء (LED)، وتوليد نغمات موسيقية وأصوات تحذيرية. في (السيناريو) الثاني، تم استخدام واحدة من الإشارات الناتجة لتوليد موجة جيبية، ثم رُشحت باستخدام مرشح مضاف إلى التصميم، مما يجعل النظام يعمل كمولّد إشارات. في السيناريو الثالث، تم استخدام إحدى إشارات (PWM) الناتجة للتحكم بسرعة محرك من خلال تغيير النسبة المئوية لدورة العمل. في هذا السياق، يعمل النظام المطور كمحول تناظري-رقمي (DAC) قادر على التحكم بالنظم التناظرية من بيئة رقمية. النظام المقترح صغير الحجم، ومنخفض التكلفة، وقابل للتوسعة، ويولد إشارات دقيقة.

الكلمات المفتاحية: محول رقمي-تناظري، تحكم بالمحرك، دورة العمل، مرشح تمرير ترددات منخفضة، توليد موجة جيبية.

INTRODUCTION

Pulse width modulation (PWM) is a technique used for control in a wide range of applications, such as control of power converters, control of motor speed, control of light emitting diodes (LEDs), and control of video displays. In addition, it can be used as counters, and for generating music tones. The PWM techniques are widely used for switching power converters, mainly in AC-to-DC rectifiers (Yoo et al., 2007), DC-to-AC inverters (Amorndechaphon, 2016), and power converters (Singh et al., 2018). Moreover, PWM signals are used for power control of mobile phones (Karthikeyan et al., 2011), sound applications (Estes et al., 2005), and audio applications (Liang et al., 2011). Furthermore, they are used for LED drivers (Abdelmessih et al., 2016), for LED video display application (Svilainis, 2012), for mobile LCDs (Park et al., 2014), and for wave generation (Sreekanth & Moni, 2013).

Figure 1 shows typical PWM signals with different duty cycles. The duty cycle determines

the "ON" time of the PWM signal, which varies the width of the pulse according to a pre-defined value. If applied to LEDs, a duty cycle of 10% means 10% of the time-period, the light will be "ON", and a duty cycle of 30% means 30% of the time-period, the light will be "ON", etc.

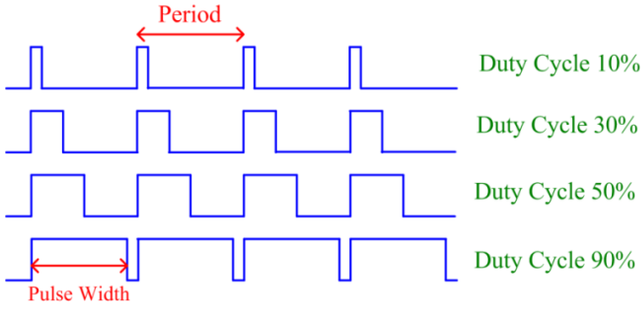


Figure 1. PWM signals with different duty cycles

Equation (1) demonstrates the relationship between the duty cycle, the pulse width, and the period.

$$Duty_Cycle = \frac{Pulse_Width}{Period} \times 100\% \quad \ldots\ldots (1)$$

Depending on the duty cycle, control signals generated from the PWM can be applied in different applications, for example, to control the speed and direction of motors, the light intensity of LEDs, etc. However, in some applications, the required frequency is high that the resolution obtained with classical techniques is not enough (de Castro et al., 2007). These days, FPGAs are small size and not expensive. The low-cost Cyclone® II FPGA board is ideal for PWM signal generation, with low-power consumption, and high performance. Moreover, the FPGA-based PWM has a high-switching speed and accurate signals, which give the PWM signals the property of precise control. Therefore, this paper proposes a generation of multiple-frequency PWM signals based on the resources available in the FPGA Cyclone IV core board. Thus, control PWM signals are produced and used in three practical scenarios, to generate audio tones and control LEDs, to generate a sine wave, and to control a motor speed. Concurrent processing and concurrent generation of multiple signals are necessary in many applications such as automotive sector, broadcasting, consumer electronics, and industrial applications. The proposed solution is low-cost, reliable, and compact. Moreover, it provides accurate PWM signals, good performance and control characteristics. Other benefits inherited from the use of FPGAs Cyclone IV include system integration, design reuse, low-power consumption, and scalability (Intel FPGAs, 2021).

The remainder of the paper is organized as follows. Section II introduces a literature review. Section III introduces the FPGA platform used in this paper, and the developed environment. While section IV introduces the results and three practical scenarios, section V concludes the paper.

LITERATURE REVIEW

The speed control of motors can be implemented using a driver circuit based on a microprocessor, a personal computer, a microcontroller, a programmable logic controller (PLC), or an FPGA. Researchers (Payak and Kumbhar, 2015) proposed a motor speed-control based on a simple PWM technique produced by an FPGA board. The FPGA signals have the control on the pulse width, which is used for firing an inverter. The inverter supplies the power to the driver circuit as per variation of the PWM. The control is accurate and fast, and the design is compact and low-cost.

Researchers (Kodama and Koutaki, 2019) described the fabrication and control of a robot that plays an acoustic guitar. The robot performs linear movement of solenoids and performs the fretting and picking operations in playing guitars. The strength and weakness of the sound is expressed by adjusting the operation of the solenoid using PWM control.

The research of (Mondal and Sharma, 2019) implemented an FPGA-based low power music system and digital data transmission environment. The output is taken from the headphone jack using PWM, and the music system provides an excellent music data to the audio output pin in real-time.

In order to solve the limitations and problems of a local music instrument, researchers (Saragih et al., 2020) developed a smart system that can automatically play the instruments notes. The instrument is driven by a DC motor, of which its speed is regulated using a PWM pin of an Arduino-based microcontroller. The Arduino program is remotely operated through the commands of an android application on a smart phone, via Bluetooth. The developed instrument has a frequency error of 0.49%, a vibration error of

3%, and a vibration error controlled by the PWM of 1.15%.

A monolithic controller for pulse width modulated (PWM) DC-to-DC converter is presented in the work of (Lu and Wu, 2009) for a LED driver circuit. For LED lighting, both the digital and analog dimming modules were integrated onto a chip, which were used to meet the demands of the two kinds of dimming applications respectively.

The paper of (Jung et al., 2010) presents a new dimmer using two active switches for AC LED lamps. The control method of the proposed dimmer is based on the pulse width. Compared to the conventional phase-controlled dimmer, the proposed PWM dimmer produces sine wave without harmonics problem. Furthermore, the proposed control method does not amplify the light flicker due to independence of the input voltage. The experimental result shows that the proposed PWM dimmer has good performance.

The work of (Martins et al., 2017) presents a real-time data monitoring to reduce automatically the brightness depending on the frames displayed on a large-scale LED panel. It employs a PWM algorithm implemented into a FPGA that takes into account the inferred power and if it exceeds a predetermined value, it dynamically reduces the power preventing overheating of drivers and connections.

The relationship between music rhythms and the output colors of red-green-blue-light-emitting-diode (RGB-LED) lamp is studied in the work of (Guo et al., 2019). Colors of the RGB-LED lamp are controlled by music rhythms. The study aims at solving the problem of matching the music rhythms and the light colors. The colors of the tricolor RGB are controlled by changing the ratio of pulse width modulation (PWM) generated from an STM32 single-chip microcomputer. The experimental results show an improvement in the control of the light colors by the music rhythms.

Multichannel PWM generator for control of LED brightness in automotive applications is presented in the work of (Wojtkowski, 2018). In some automotive applications, there is a need of multichannel control of many LED entities, which is necessary for independent control of each lighting channel. Unlike typical hardware solutions, the presented generator is based on microcontroller-based software. The solution is low-cost and easy to implement.

The research work of (Sreekanth and Moni, 2013) presents a reprogrammable architecture to implement the amplitude modulated triangular carrier pulse width modulation (AMTC-PWM) with perfect reproduction capability. The AMTC-PWM method is a natural sampled PWM method, which can extend the linearity of the sinusoidal PWM. Thus, it eliminates the need of over modulation in the pulse-dropping region to reach the square wave boundary. The architecture is implemented using the FPGA Spartan 6 family device LX45 from Xilinx.

SYSTEM ARCHITECTURE

The objective of this paper is to design and develop hardware environment for the generation of multiple-frequency PWM signals using an FPGA development board. FPGAs excel in concurrent processing, and hence, concurrent multiple PWM signals are generated using reconfigurable variables that represent frequencies and duty cycles. The first subsection describes the FPGA development board from WaveShare that hosts the Cyclone IV, and the second subsection describes the designed and developed environment.

The FPGA Development Board

This subsection describes the FPGA development board used in this work, which is the OpenEP4CE10-C from WaveShare. It is an FPGA development board that consists of the motherboard DVK600 and the FPGA core board EP4CE10F17C8N, which is the Cyclone IV. The board contains other accessories required for the operation of the core board and for basic testing, as shown in Figure 2. It has an FPGA core board connector for easily connecting core boards. Moreover, it has eight, sixteen, and thirty-two inputs and outputs (8I/Os_1, 8I/Os_2, 16I/Os_1, 16I/Os_2, 32I/Os_1, 32I/Os_2, 32I/Os_3) interfaces for connecting accessory boards and modules. All the I/O interfaces are capable of being operated as universal synchronous/asynchronous receiver/transmitter (USART) protocol, inter IC communications (I2C) protocol, and serial peripheral interface (SPI) protocol; and capable of driving devices such as USB and Ethernet. Furthermore, it has an SDRAM

interface for connecting SDRAM accessory board, an LCD interface for connecting an LCD1602, a ONE-WIRE protocol interface that connects to the temperature sensor DS18B20, a 5V DC jack, a joystick, a buzzer for testing audio tones, a potentiometer for the LCD1602 contrast adjustment, and a power switch.

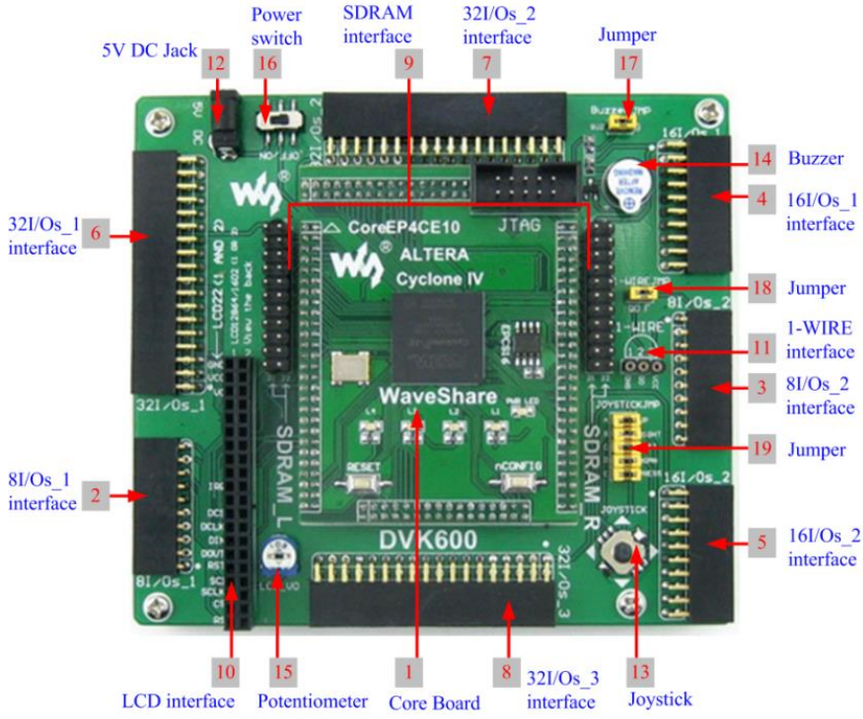


Figure 2. The FPGA development board from WaveShare for FPGA Cyclone IV

As shown in Figure 2, the EP4CE10F17C8 core board consists of voltage regulators, EPCS16 onboard serial FLASH memory for storing code, power indicator, four LEDs for testing, reset button, nCONFIG button for re-configuring the FPGA chip, 50MHz active crystal oscillator for clocking, JTAG interface for programming, and the Cyclone IV FPGA device with the features shown in Table 1.

Table 1 Features of Cyclone IV core EP4CE10F17C8

Feature	Value
System Frequency	50MHz
Core Voltage	1.2V
Inputs/Outputs	180
Logical Elements (LEs)	10320
RAM	414kB
Phase-Locked Loops (PLLs)	2
Programming Interface	JTAG

The next subsection describes the environment design in more details using the resources and features of Cyclone IV, mentioned above.

Environment Design and Development

This subsection describes the design of a hardware module, which is written in VHDL for the FPGA Cyclone IV, and generates multiple-frequency (PWM) signals. The generated PWM signals, come out of the module, are based on the duty cycle. The value of the duty cycle is set by the user in the definitions section of the entity as a generic value. Other configurable values that are set as generics by the user in the definitions section include frequencies of the generated PWM signals, bit resolution, and the system frequency, which is 50MHz in the case of the EP4CE10 core. In more details, the duty cycle and the frequencies are reconfigurable by changing the variables values in the entity section of the VHDL program.

When the module is set to generate multiple frequencies concurrently, one PWM signal is generated per frequency. In this paper, the number of frequencies is set to three, and hence the module generates three PWM signals, in addition to another three that are generated from the inverse states of the original signals. In total, six signals are produced concurrently, and the processing is running concurrently as well via three separate processes.

A schematic diagram of the developed module, which generates multiple-frequency PWM signals, is shown in Figure 3, based on the

FPGA Cyclone IV. The input is the System_Clock, which is 50MHz. The outputs, which are Cyclone IV output pins, are PWMout[1..3] and PWMinverse[1..3] pins. These signals control external LEDs and a buzzer. The buzzer produces alarm sounds or music tones, depending on the frequency defined by the user as a generic value in the entity section. The input frequencies and duty cycles are 440 Hz with 12.5% duty cycle, 3Hz with 25% duty cycle, and 16 kHz with 50% duty cycle, respectively. These output signals are employed in three practical scenarios. The 440 Hz tone is routed to the buzzer pin and a LED, the 3Hz signal controls two LEDs, and the 16 kHz sine wave signal is routed to an add-on RC low pass filter (LPF) circuit for smoothing. The LPF resistor and capacitor values are 25Ω and 0.47µF respectively. The third scenario employs one of the signals to control a motor speed.

The signals in the register transfer level (RTL) are wires that connect the process variables to the output pins of the FPGA board. Each process produces two PWM signals based on counters that are triggered via the system clock. Each process calculates a counter value that is compatible with its duty cycle specified in the entity section of the VHDL program. Each clock cycle the counter increases by one and an "if" statement checks whether the intended value is reached according to the duty cycle, otherwise the counter continues counting to produce the logic one, which is interpreted as high at the FPGA pin. If the counter reaches the intended value according to the duty cycle, it produces logic zero, which is interpreted as low at the FPGA pin. However, the opposite values are assigned for the inverse signals (PWMinverse). Therefore, for LED2 and LED4 that flashes three times per second, when LED2 is "ON" LED4 is "OFF" and when LED2 is "OFF" LED4 is "ON".

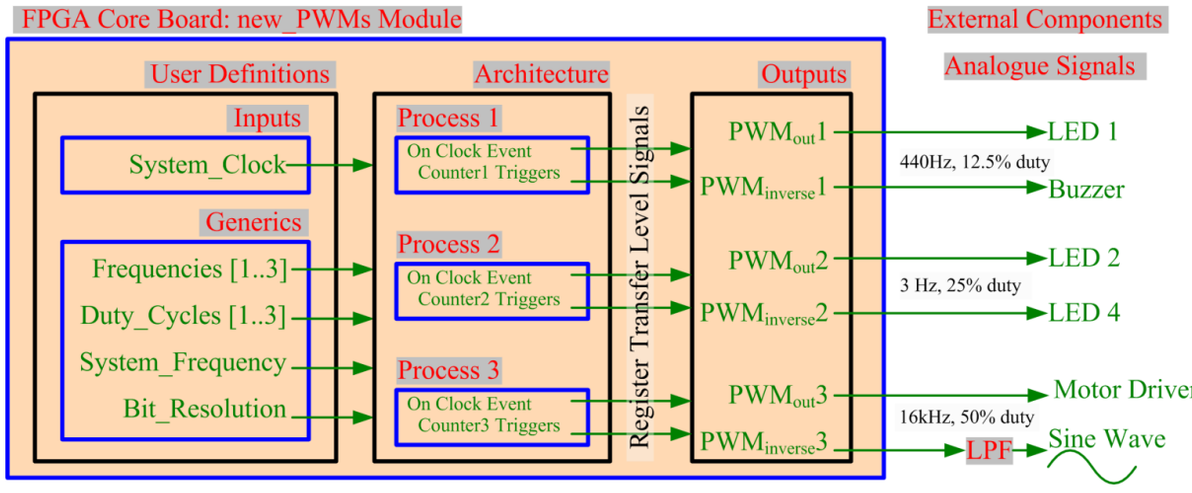


Figure 3. The developed environment

As appear in Figure 3, the environment consists of two parts, a digital part represented via FPGA, and an analogue part represented via external components. The digital part is developed using VHDL, and resides inside the FPGA core. The analogue part represents the external components, and resides on the motherboard DVK600. However, the motherboard does not have a built-in LPF. Hence, an external filter is designed and built to obtain a sine wave from the sixth PWM signal. The details of the filter design and analysis are demonstrated in the next section.

RESULTS AND PRACTICAL SCENARIOS

The integrated development environment of the FPGA Cyclone IV is the Quartus II, version 13.0, web edition. Table 2 shows the result that is taken from the Quartus II after compilation, which demonstrates a successful implementation and synthesis of the developed module on the EP4CE10F17C8 core.

For the results illustrated in table 2, the input frequencies and duty cycles are 440Hz with 12.5% duty cycle, 3Hz with 25% duty cycle and 16 kHz with 50% duty cycle, respectively. The total logic

elements (LEs) are 135, and the total registers are 61. This is an indication about the developed environment, which is compact, reliable, and low-cost. Since the digital circuit produced by the RTL viewer is very huge, it is not included in the paper.

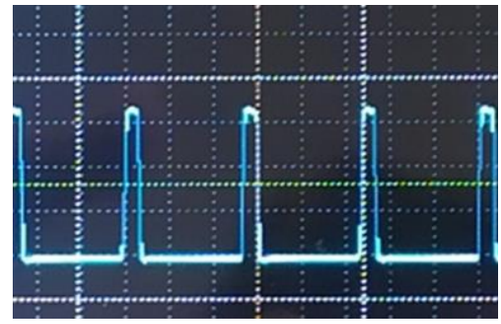
Table 2 Synthesis of the Developed Module on the FPGA

Feature	Value
Flow Status	Successful - Fri Mar 12 16:37:30 2021
Quartus II 32-bit Version	13.0.0 Build 156 04/24/2013 SJ Web Edition
Top-level Entity Name	new_PWMs
Family	Cyclone IV E
Device	EP4CE10F17C8
Total logic elements	135 / 10,320 (1 %)
Total combinational functions	134 / 10,320 (1 %)
Dedicated logic registers	61 / 10,320 (< 1 %)
Total registers	61
Total pins	7 / 180 (4 %)
Total virtual pins	0
Total memory bits	0 / 423,936 (0 %)
Embedded Multiplier 9-bit elements	0 / 46 (0 %)
Total PLLs	0 / 2 (0 %)

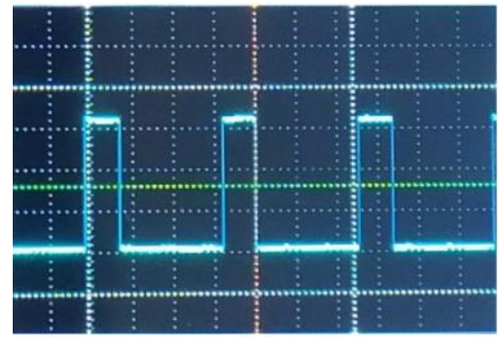
Using the DSO201 nano oscilloscope, snapshots of the obtained signals are taken from the screen of the pocketsize oscilloscope. These snapshots are illustrated in Figure 4 with the generated pulses depending on the specified duty cycles. However, the sketches produced by the nano oscilloscope are estimated based on the oscilloscope circuits, and does not reflect the true values produced by the FPGA. The pocketsize oscilloscope is basic oscilloscope, which gives an indication about the measured signals, and therefore these results are indicative.

Concurrent processing and concurrent generation of multiple signals are necessary in many applications such as automotive, broadcasting, consumer electronics, and industrial applications. The generated PWM signals are tested in three practical scenarios.

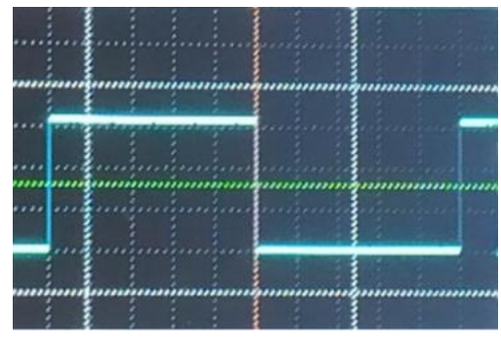
The first scenario is concerned with the concurrent generation of alarms and flashers by the buzzer and three LEDS. The LED number 1, LED number 2, and LED number 4 are working concurrently, producing alarms in a specific sequence described above. The buzzer produces a continuous alarm using the “A” tone, which has a frequency of 440 Hz. Such a practical scenario is widely used not only for alarms in industrial applications but also in automotive.



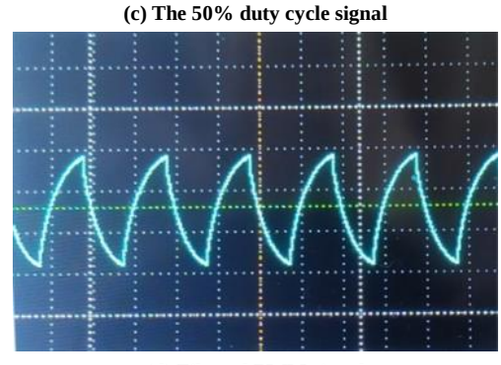
(a) The 12.5% duty cycle signal



(b) The 25% duty cycle signal



(c) The 50% duty cycle signal



(d) Filtered PWM signal

Figure 4. Snapshots taken from the screen of a pocket oscilloscope for each generated PWM signal.

The sixth PWM signal has a 50% duty cycle, and a frequency of 16 kHz. It is injected in an external, add-on, simple RC LPF, which smooths the sine wave. However, the output was not very smooth, as shown in Figure 4 (d). Therefore, in the second scenario, another filter is designed using PSpice software, student version. The filter is fourth order, Butterworth LPF, with 16 kHz cutoff

frequency. As shown in Figure 5, the filter consists of two stages of the Sallen-Key configuration that employs an operational amplifier with a specific arrangement of resistances and capacitances; each stage is a second order Butterworth LPF, and the cutoff frequency for each stage is calculated using eq. (2) and eq. (3) respectively:

$$f_{C1} = \frac{1}{2\pi\sqrt{R_5 C_3 R_4 C_4}} \quad \ldots (2)$$

$$f_{C2} = \frac{1}{2\pi\sqrt{R_3 C_1 R_2 C_2}} \quad \ldots (3)$$

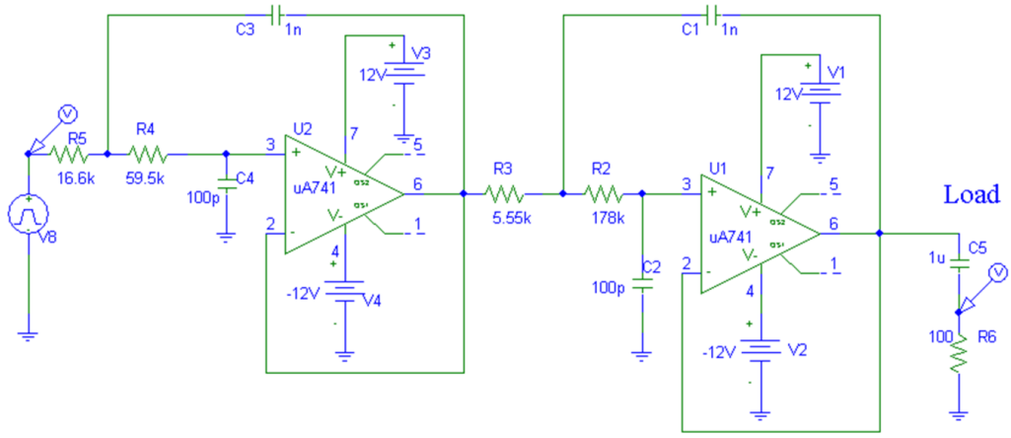


Figure 5. Fourth order, Butterworth LPF.

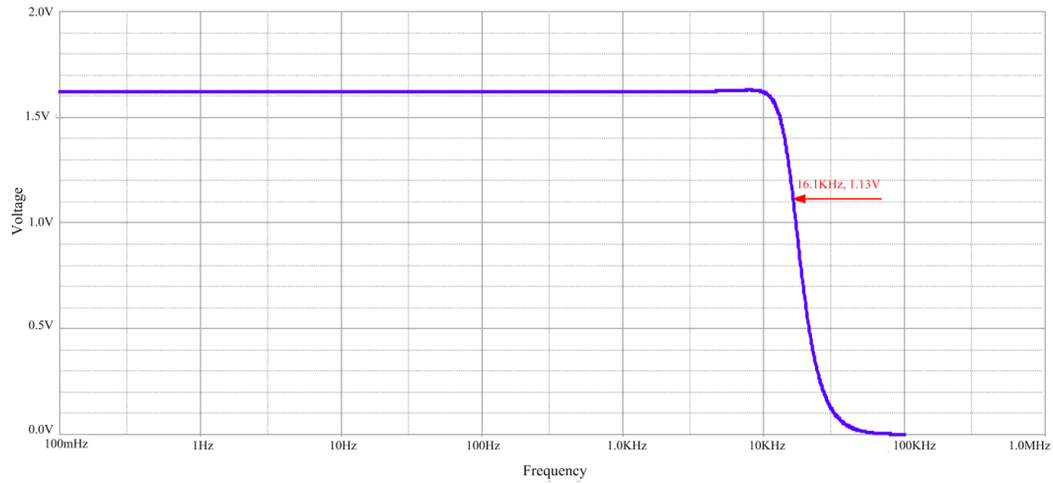


Figure 6. AC analysis of the fourth order, active, Butterworth LPF.

According to eq. (2), the cutoff frequency of the first stage is 16.01 kHz. According to eq. (3), the cutoff frequency of the second stage is 16.01 kHz as well. As shown in Figure 5, a capacitor of 1μF is used in series with a load of 100Ω in order to remove the DC component that may leak in the load resistor. The input frequency of the filter is 16 kHz, the duty cycle is 50%, and the maximum input voltage is 1.62V, which are the specifications of the FPGA pin that produces the sixth PWM signal. At the cutoff frequency, which is 16 kHz, the output voltage is 0.707 of the input voltage, or 1.14V. However, the result of the AC analysis shown in Figure 6 and made up to 100 kHz, estimates the cutoff frequency as 16.1 kHz and the output voltage as 1.13V. The AC-analysis is made using an AC sine-wave voltage source, and the transient analysis is made using a pulse-wave voltage source.

The sketch shown in Figure 7 demonstrates the transient analysis of the designed filter in the first 500 microseconds. The input signal is square wave (PWM of 50% duty cycle) with 62.5 μs period (16 kHz-frequency). The filter output is sine wave. The transient analysis shows a stable response of the filter in the third cycle. The input frequency is 16 kHz, and hence the period is 62.5 microseconds, which means that the stability of the

filter starts to appear at 200 µs. The output is a sine wave that swings between -0.71V and +0.71V after stability, and without the DC component, which is removed by the 1µF capacitor. The developed system produces a sine wave, generated from the FPGA-based PWM signal, which makes the developed system to act as a function generator that produces PWM and sinusoidal waves.

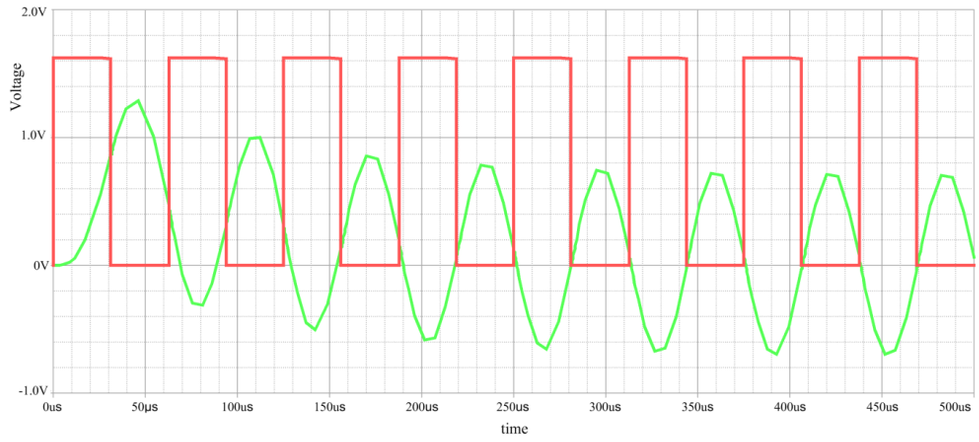


Figure 7. Transient analysis of the fourth order, active, Butterworth LPF.

These signals are in use for communications, electric circuits, consumer electronics, broadcasting, etc. In this context, the PWM signal converted the digital values, produced by the FPGA pin, into an analogue signal, and worked as a simple digital to analogue converter (DAC). In fact, the PWM is efficient to control analogue components and electronic circuits from digital FPGA modules.

The third scenario is concerned with the speed control of a DC motor using one of the generated PWM signals. DC motors are in use in many applications, include but not limited to lathe machines, centrifugal pumps, fans, blowers, conveyors, lifts, weaving machine, spinning machines, etc. (Barua and Abedin, 2018). There are many types of DC motors, which are chosen according to the intended application. Industrial applications require an accurate speed control for precise movement, in addition to avoid safety problems. In fact, FPGAs can generate accurate PWM signals required for motor control. Hence, a third scenario is proposed here, as shown in Figure 8 to control the speed of a DC motor by changing the duty cycle of the PWM signal.

A mini DC motor is used in this scenario, which operates on a voltage ranges from 0.5V to 6.0V. The motor, shown in Figure 8, is connected in series with the collector of a general-purpose transistor of type 2N2222A. In addition, a protective fast-switching diode is connected in parallel to handle spikes. A ceramic capacitor is connected in parallel to compensate for the inductive reactance caused by the coils of the motor at the selected frequency of the PWM signal, which is 16 KHz.

The audible noise (humming sound) generated by the DC motor while operating, is an effect of driving it with switched current produced by the PWM signal. The magnetic field causes the enclosure and coils to act as a speaker, and hence, generates the noise at the PWM frequency. In general, a PWM frequency over 16 kHz, which is out of the audible range, reduces the humming noise. However, choosing a PWM signal that has higher frequency, the inductance of the motor starts to have higher effects, the motor dissipates more heat, and hence more power losses. On the other hand, a PWM signal that has a PWM frequency in the audible range causes noisy humming sound.

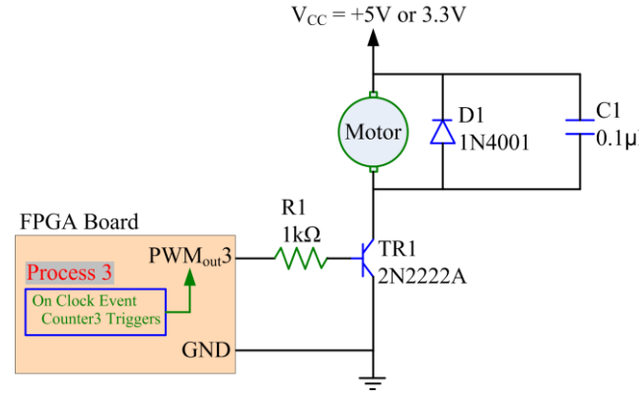


Figure 8. Circuit driver for the speed control of the DC motor

As mentioned above, the motor has coils, and hence it has an inductive reactance value that

is influenced by the selected frequency (16 kHz) and the coils inductance (1 mH), as shown in eq (4):

$$X_L = \omega \cdot L = 2 \times \pi \times f \times L \quad \ldots\ldots (4)$$

Accordingly, the inductive reactance is 100.5Ω. Together with the coils resistance, they form an RL filter, which will have a noticeable effect in high frequencies. Therefore, a capacitor of 0.1μF is added in parallel to the motor's terminals. The capacitor value is selected depending on eq. (5), which evaluates the capacitive reactance that must compensate for the inductive reactance:

$$X_C = \frac{1}{\omega \cdot C} = \frac{1}{2 \times \pi \times f \times C} \quad \ldots\ldots (5)$$

The goal of driving a DC motor by a PWM signal with a certain duty cycle is to provide it with a portion of the full DC voltage, and hence speed control can be achieved by changing the duty cycle percentage.

Table 3 and table 4 illustrate this idea. The motor terminals voltages are measured according to the changes in the duty cycle that is adjusted by the user. Measurements are taken for transistor voltage (VCC) of 3.3V and 5.0V. The voltage at the FPGA pin is varied according to the duty cycle of the PWM signal.

Table 3 Measured motor terminals voltage and speed according to duty cycle changes at V_{CC}=3.3V

Duty Cycle (%)	PWM Pin Voltage	Terminals Voltage	Speed (rpm)
12.5	0.40	0.02	0
25.1	0.81	0.07	0
37.6	1.21	0.34	510
50.2	1.62	0.75	1125
56.5	1.83	0.98	1470
62.7	2.02	1.12	1680
75.0	2.42	1.50	2250
87.8	2.83	1.90	2850
94.1	3.04	2.22	3330
99.6	3.26	2.34	3510

Table 4 Measured motor terminals voltage and speed according to duty cycle changes at V_{CC}=5.0V

Duty Cycle (%)	PWM Pin Voltage	Terminals Voltage	Speed (rpm)
12.5	0.40	0.05	0
25.1	0.81	0.37	555
37.6	1.21	0.90	1350
50.2	1.62	1.50	2250
56.5	1.83	1.83	2745
62.7	2.02	2.08	3120
75.0	2.42	2.75	4125
87.8	2.83	3.51	5265
94.1	3.04	3.82	5730
99.6	3.26	4.10	6150

In ten experiments, ten different duty cycle values have been applied in the generic part of the entity section. Each time, the voltage at the FPGA pin (PWMout3 signal) is measured, and the voltage at the motor's terminals is measured as well. These results of the ten experiments are illustrated in table 3. The motor speed is calculated (in revolutions per minute, rpm) according to the measured voltage at the terminals of the motor. A typical speed of 9000 rpm is obtained when a voltage of 6.0V is applied across the motor's terminals. Thus, the speed is calculated according to eq. (6):

$$Speed = \frac{Terminal_Voltage}{6.0} \times 9000 \quad \ldots (6)$$

The maximum voltage at the FPGA pin is 3.3V when the duty cycle is 100% and 0.0V when the duty cycle is 0.0%. This voltage is applied to the base of the transistor, which controls the current flow between the collector and the emitter. The extra voltage that does not apply to the motor is consumed by the transistor as collector-to-emitter voltage (VCE) drop, which is necessary for the operation of the transistor itself. For example, when a duty cycle of 50% is applied to the PWM signal, a voltage of 1.62V is driven out of the FPGA pin to the transistor base, which switches the transistor "ON" and "OFF" 16000 times per second (16 kHz frequency). The measured voltage on the motor terminals is 1.5V, and hence the VCE is 3.5V since the VCC value is 5V. This is calculated via eq. (7):

$$V_{CC} = V_{Terminals} + V_{CE} \quad \ldots (7)$$

These values are illustrated in table 3 and table 4.

The results of table 3 and table 4 are plotted in Figure 9. The relationship between the FPGA pin voltage and the specified duty cycle is plotted in the top-left of the sketch, which is linear relationship. The curve that represents the relationship between the measured voltage at the motor's terminals and the duty cycle is plotted in the top-right of the sketch. The duty cycle is taken in logarithmic scale to show percent changes. Moreover, the curve that represents the relationship between the motor speed and the specified duty cycle is plotted in the bottom-left of the sketch. The speed is in thousands, so the scale is logarithmic to respond to skewness towards

large values. In addition, the relationship between the motor terminals voltage and the motor speed is plotted in the bottom-right of the sketch. The speed, which is located in the x-axis, is logarithmic scale as well for the same reason mentioned above. Four curves are plotted for two values of the transistor feed voltage (VCC), of 3.3V and 5.0V respectively. Both have almost the same response, and hence both lines are identical in the fourth plot.

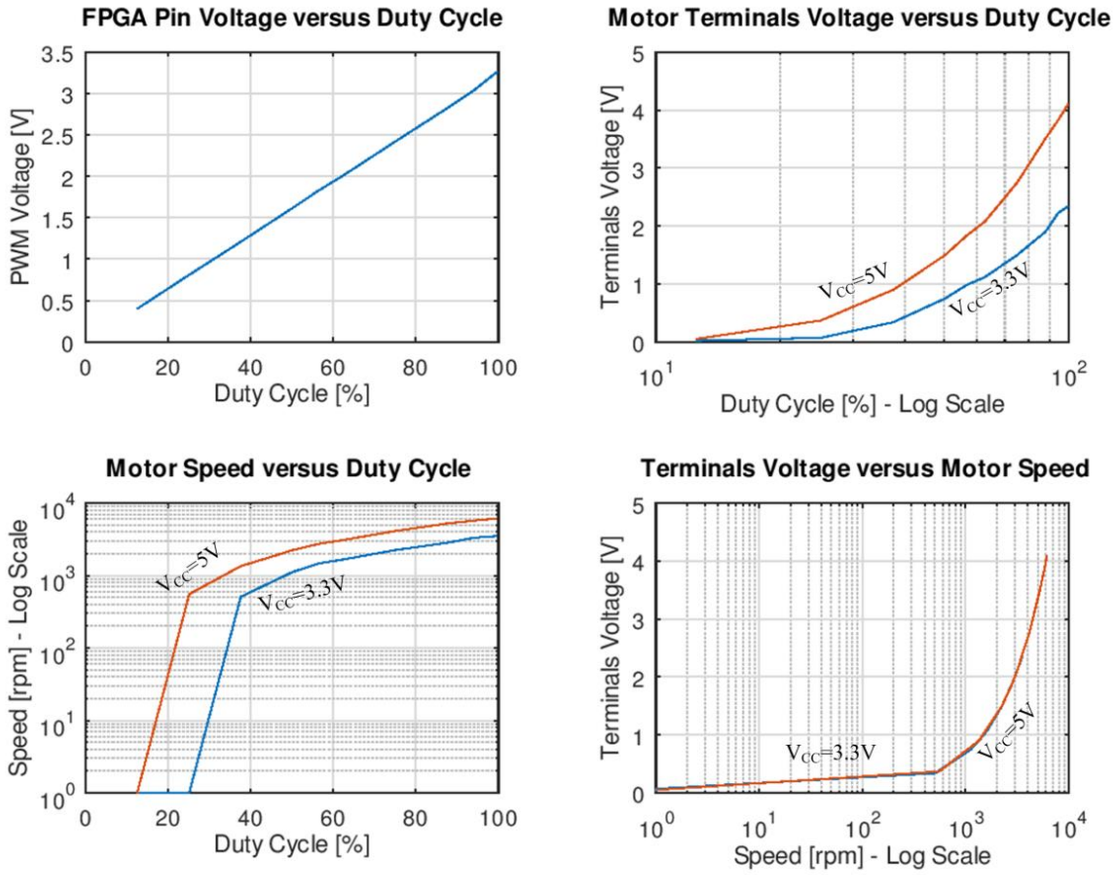


Figure 9: Measured motor terminals voltage, FPGA pin voltage, and speed according to duty cycle changes

CONCLUSION

The paper describes a successful implementation and synthesis of FPGA-based generation of concurrent multiple-frequency PWM signals to control LED flashers and motor speed, and to generate audio tones and sinusoidal wave. Many applications, such as automotive sector, consumer electronics, broadcasting, and industrial applications, require the concurrent generation of accurate multiple-frequency PWM signals. Although separate ICs exist in the market, synthesis of PWM signals in FPGAs can integrate these components into the embedded architecture. This results in reduced cost, power consumption, and circuit board space, which improves system reliability and performance. The developed environment is compact and low-cost, and the generated signals are accurate. As a proof of concept, this solution is used in three practical scenarios. The first scenario is concerned with the control of LED flashers and audio tones. This solution can be found in many industrial applications and the automotive applications as well. The second scenario is concerned with the generation of waveforms that are smoothed via an add-on Butterworth LPF. This makes the developed system to act as a function generator that produces PWM signals and sinusoidal waves. Hence, the PWM signal converted the digital values, produced by the FPGA pin, into an analogue signal, and the system worked as a simple DAC. Such signals are required in many fields of applications such as communications, electric circuits, consumer electronics, automation, etc. The third scenario is concerned with the generation of PWM signal to control the

motor speed by changing the duty cycle percentage. Voltage measurements are taken from the FPGA pin that produces the PWM signal based on a variable duty cycle value. The voltage on the motor's terminals is measured as well, and then the speed of the motor is calculated. Ten experiments are executed based on various duty cycle values, and then results are plotted in four curves. The solution is applicable to other DC motors. In fact, the three scenarios may exist in one application such as cars or an industrial application, where digital control of a production line, for example, employs them all in one solution. Moreover, the developed environment can be used for education of PWM and related applications such as the digital control of analogue systems.

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Developing a Smart IoT based Traffic Management System

تطوير نظام ذكي لإدارة السير وتنظيم المرور استناداً إلى إنترنت الأشياء

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ABSTRACT

This research paper emerged from the urgent need to address traffic offenses and the accompanying accidents and reduce traffic congestion by developing a smart traffic management system (STMS). The proposed system serves the competent authorities (e.g., the traffic department and the traffic police) in traffic control to reduce traffic offenses and accidents and preserve properties and lives. As such, the system will target drivers, regardless of the type of vehicle they drive. The system handles three major offenses: Running a red light, over-speeding, and parking in a prohibited space. The system consists of two main parts, a hardware that consists of controllers and sensors to track offenses as soon as they occur and a web application that records these offenses. It comprises the hardware and software components to issue e-tickets to be sent to offenders in short messages specifying the time, type, and fine of each offense ticket to prevent them from recommitting offenses. It also provides a congestion control model at traffic signals on road junctions. In the system analysis phase, data collection was conducted using two instruments, a questionnaire as a quantitative instrument, which was analyzed using the statistical package for the social sciences (SPSS), and personal interviews as a qualitative instrument, which was analyzed through thematic coding and content analysis to classify themes and subthemes. In the development phase, a prototype was developed and tested for running the red light offenses, and the results were generalized to the other types of offenses because they are built on the same basis. The obstacles and challenges were identified, and recommendations were set on the ways to overcome these offenses by involving the targeted drivers and the community in the development process to raise awareness in this regard. In addition, the proposed system can serve the community by providing a transparent system, and at the same time, increasing the government income and reducing the risk of traffic accidents resulting from offenses.

Keywords: Fines, IoT, Issuing e-Tickets, Over-speeding, Running a Red Light, Smart City, Track and Detect Offenses, Traffic Accident, Traffic Management System, Traffic Offense.

الملخص

تنبع فكرة المشروع البحثي من الحاجة الماسة إلى معالجة مشكلة مخالفات السير، وضبط أنظمة المرور، وتقليل الازدحامات الخانقة. إذ يسهم النظام الجهات المختصة ويخدمها (دائرة السير وشرطة المرور) في ضبط نظام المرور والحد من المخالفات، وبالتالي تقليل الحوادث المرورية والحفاظ على الممتلكات والأرواح. وبذلك فهو يستهدف فئة السائقين بغض النظر عن نوع المركبات التي يقودونها. يعالج النظام ثلاث مخالفات رئيسة هي تجاوز الإشارة الحمراء، وتجاوز السرعة، والاصطفاف الممنوع. يتكون النظام من جزأين أساسيين، المعدات الإلكترونية من مجسات ومستشعرات ومتحكمات لرصد المخالفات فور حدوثها، ونظام محوسب وقاعدة بيانات تسجل هذه المخالفات. فهو يجمع بين المكونات المادية والبرمجية لتمكنه من إصدار مخالفات إلكترونية فورية لمرتكبيها، تصلهم عبر رسالة قصيرة تحدد وقت المخالفة وطبيعتها وغرامتها، لمنعهم من ارتكابها مرة أخرى. كما يوفر نموذجًا لمراقبة الازدحام المروري، والتحكم بزمن إشارات المرور على مفترقات الطرق. تم العمل على جمع البيانات وتحليلها من خلال أداتين، الاستبانة كأداة كمية، وقد تم تحليلها باستخدام حزمة التحليل الإحصائي (SPSS)، كما تم تدعيمها بالمقابلة الشخصية كأداة نوعية، وتم تحليلها باستخدام الترميز وتحليل المحتوى، وإعداد المحاور وتصنيف النتائج. كما تم إعداد النموذج الأولي (Prototype) للجزء الأول من النظام الخاص بتجاوز الإشارة الحمراء، وتم اختباره وتعميم النتائج على بقية المخالفات كونها بنيت على الأساس ذاته. وتلخصت طرق الإفادة من نتائج البحث في تعميمها ونشرها، يضاف إلى ذلك تحديد المعيقات والتحديات، والتوصيات المتعلقة بسبل التغلب عليها، وإشراك الفئة المستهدفة من السائقين وأفراد المجتمع في عملية التطوير، وزيادة الوعي بهذا الشأن، وخدمة الحكومة

والمجتمع بتوفير نظام شفاف يزيد من دخل الحكومة، ويقلل مخاطر الحوادث المرورية الناجمة عن المخالفات.

الكلمات المفتاحية: إنترنت الأشياء، إصدار مخالفات إلكترونية، تجاوز الإشارة الحمراء، تجاوزالسرعة، حوادث السير، غرامة، كشف المخالفة ورصدها، مخالفة السير، المدن الذكية، نظام إدارة المرور.

INTRODUCTION

Recently, in light of the remarkably vast spread of the number of vehicles in Palestine and the inadequate infrastructure in the Palestinian cities, the number of traffic accidents has increased steadily, causing a significant loss in lives, public and private properties (Ministry of Transportation, 2020). Prior to delving deep into the research topic, it is essential to identify and define the most important concepts in the context of STMS. Traffic signs direct the flow of traffic and display the rules of the road. Warning signs are triangle-shaped signs that show changes in the road's structure, whereas guide signs are round-shaped signs that regulate the traffic movement and clarify where and when vehicle crossing is allowed. The signs' height is 1.5-2.5m and is placed 1-4m away from the edge of the road, such as the stop and slow signs. In addition, road markings are effective tools to regulate traffic movement in streets; usually, they are used to improve the effectiveness of traffic signs and guide the drivers to road instructions directly. Traffic signals/lights are used to regulate the movement of all types of vehicles. By altering the color of the light, drivers and pedestrians know when to stop and when to renew the movement (Abu Ahmed, 2003).

Internet of Things (IoT) is a network of devices interacting with each other, where they can sense, capture and transfer data over the Internet without any human intervention. Humans have limited time, attention, and accuracy in capturing data of things in the real world. With the help of computers and the Internet, they will be able to gather sufficient data that enables them to track and count everything reducing time and cost. IoT is based on four stages: actuators and sensors, data acquisition, pre-processing (edge analytics), and cloud analytics. IoT platforms can be used to collect data within a wide geographic area with remote monitoring and control tools and process them for early warning. Therefore, IoT applications can be used in several fields, such as smart cars, homes, transportation, healthcare, etc., to constitute smart cities (Bharani, 2020).

This paper was set out to find suitable solutions by employing smart cities, mainly the Internet of Things (IoT) in the transportation domain. The proposed solution assists the traffic department and the traffic police to manage, prevent and detect traffic offenses. This research aims to design and build a Smart Traffic Management System (STMS) that integrates hardware components such as cameras and sensors to capture related data. The detected offenses are recorded on a central database on the cloud, and their e-tickets are issued and sent to the offenders using an SMS server. Accordingly, the essential national benefit of the proposed STMS stems from setting out precautions that minimize the risks and reduce damages of public and private properties and loss of people's lives due to traffic accidents resulted from offenses, as the first stage of Palestinian smart cities. It automatically detects different types of offenses and issues e-tickets accurately. Sustainability is granted through traffic offense fines, especially compensation from undetected offenses due to the lack of human resources or the circumvention of drivers from paying the fines.

This research is limited to three traffic offenses, including running a red light, over-speeding and parking in prohibited public places. The developed prototype was applied to a sample of both vehicles and traffic lights that were tested for a specific period while keeping records of the readings and results. The study population included drivers of public transportation in Ramallah and al-Bireh district, where a sample was selected to complete the data collection instruments, entailed conducting a survey on their opinions using questionnaires and interviews. The data were analyzed using the appropriate qualitative and quantitative data analysis tools based on thematic coding and SPSS, respectively. In contrast, another method was based on developing a prototype to be applied, operated, and tested in some selected locations, paving the way for building a comprehensive and broader system in future studies if sufficient funding can be allocated.

The paper consists of six sections, starting with this introduction as the first section. The second section presents a literature review. The

problem statement is covered in the third section, and the proposed STMS is depicted in the fourth section. Finally, the fifth section provides the research results and discussion, and the sixth section provides the conclusion and the recommendations.

LITERATURE REREVIEW

As part of the global smart-city agenda, digital technologies became the backbone of smart cities to enhance urban infrastructure quality. This approach will enable our cities to be efficient, green, and technologically advanced. Moreover, sustainability development has a significant impact on planning smart cities to create sustainable smart cities. In this context, we focus on enhancing the environment to reduce pollution from different resources. Therefore, attention to the combination of technology and the environment is the most efficient way to constitute the 21st century's ideal cities. The smart city transport concept is considered a future vision aiming to investigate the urban planning process and construct policy-pathways to achieve future goals. In addition, this trend will address the severe global challenges related to ecology, society, economy, and good governance (Yigitcanlar, Han & Kamruzzaman, 2020).

One of the most important issues related to the Intelligent Transportation System (ITS) and smart cities is the Traffic Management System (TMS). The ITS collects traffic-related data that enable travelers to select traveling modes and paths and departure times. With the growth of the number of vehicles recently, traffic congestions increased; thus, the number of traffic offenses increased. Information technology can provide solutions to several traffic and transportation issues, and the IoT assists in traffic-related data collection (Varun Chand & Karthikeyan, 2018).

In the motion towards smart traffic management systems, Singh, Alok, Manav, & Kandari (2019) implemented a density-based traffic controller with defaulter identification using IoT. It constitutes an offender detection module that identifies the vehicles that runs a traffic signal when the light is red. An IR sensor detects the presence of an offender at the junction and triggers a camera to take a snapshot of the plate number of the offender's vehicle using the AMCap application. The plate's image is sent to the monitoring device and is displayed on a special webpage with the incident's relevant information of the offense. In order to minimize road accidents due to over-speeding, Jeddi, Hassouna, Shahin, & Mir (2016) proposed a monitoring and transmitting device embedded in every vehicle that monitors over-speed offenses continually and sends relevant information to a central database, which in turn compares the actual speed of the vehicle with the defined speed limit of that road, and identifies offenses accordingly. A prototype device was successfully implemented and installed in a vehicle for testing and evaluation purposes. This device consists of GPS/GSM908 module, antenna, SIM card, Atmel 32 bit microcontroller, impact detector, SD card, and power supply. It records the position, time, and date from a GPS satellite in real-time, where the vehicle's speed, position and ID are transmitted to the central databased every 10s.

For vehicle identification, which is essential in TMS, some researchers used cameras and image processing of vehicle plates to extract its ID using OCR (Singh et al., 2019). Others used a vehicle-embedded device that stores the vehicle's ID with a transmitter that transmits it to a central database (Jeddi et al., 2016). But QR code could be an innovative solution, where the vehicle's ID can be inserted in a QR code that appears on the plate, then a QR reader will perform very well with high accuracy (Jichkar, Deulkar, Thakare, Bolakhe, & Vaidya, 2019). Moreover, Radio Frequency Identification (RFID), which are small electronic devices that consist of small chips and antennas, can be used for automatic vehicle identification using electromagnetic fields (Angeline, Aswini, Devadharshini, Gousalya, & Aravind, 2018). This technique can be used by traffic monitoring systems or police to identify the vehicle using an RFID reader that provides all information related to that vehicle, including previous offenses, owner's information, and if the vehicle has pending offense cases with unpaid fines. In addition, an invention was registered by (Palmer & Aharoni, 2013) in the USA for collision prediction and traffic violation detection. It refers to a system for monitoring, analyzing, and reporting traffic offenses at a predetermined area in real-time, prospectively, or retrospectively.

Yogheshwaran, Praveenkumar, Pravin, Manikandan, and Saravanan (2020) proposed an

IoT-based intelligent traffic control system that deals with emergency cases when an Ambulance is delayed due to traffic that puts saving our life in jeopardy. In their model, they considered that over-speeding is the main issue prevailing offenses and is difficult to control. In order to overcome this issue, it is necessary to force vehicle drivers to slow down and stop in probable accident areas. They developed a model that controls the speed of the vehicles forcing drivers to stop at red signals. Furthermore, Javaid, Sufian, Pervaiz, and Tanveer (2018) proposed a hybrid IoT-based STMS with an algorithm that optimizes traffic flow efficiently and manages traffic signals using an input of traffic density from cameras and sensors. They used RFID to prioritize the emergency vehicles (e.g., ambulances and fire brigade vehicles) during a traffic jam. In order to measure the effectiveness of the proposed system, they developed a prototype that is connected to a centralized database and presented the important data in a graphical format to assist the authorities in developing future road plans. On the same concept, Sharif, Li, Khalil, Kumar, Sharif, and Sharif (2018) proposed a low-cost STS to provide a better quality of service for public traffic management. They fixed low-cost sensors every 500 meters to obtain updated traffic data for further real-time processing to analyze traffic density and predict scenarios to solve traffic issues.

In order to overcome the disadvantages of traditional traffic management techniques, Das, Dash, and Mishra (2018) developed an RFID-based model that reduces installation time and maintenance cost and monitors the motion of tagged vehicles. Similarly, Rath (2018) suggested an enhanced traffic control and monitoring framework that transmits quick information with their corresponding actions using Vehicular Ad-hoc Network (VANET) with a mobile agent-based controller that depends on a congestion control algorithm to regulate the traffic flow. He carried out his experiments using NS2 simulation and obtained acceptable results with reduced delays and accidents. Moreover, Janahan, Veeramanickam, Arun, Narayanan, Anandan, and Javed (2018) proposed another model for traffic signal monitoring using vehicle counts. It optimizes the timing interval of the traffic signal based on the number of vehicles on a particular roadside. It can decrease the waiting time for the drivers to crossroad signal, using a clustering model based on K-Nearest Neighbors (KNN) supervised learning algorithm. They implemented the model on a traffic network and real-time traffic sub-networks to measure the effectiveness. The results are displayed for the Admin to monitor traffic flow using multiple IR sensors, and clients can check the traffic flow anytime.

Many researchers follow similar smart IoT-based TMSs that control traffic congestion, especially at road crossings. IoT based intelligent traffic congestion control system for road crossings (Sadhukhan and Gazi, 2018), IoT based intelligent transportation system (IoT-ITS) for global perspective (Muthuramalingam, Bharathi, Kumar, N. Gayathri, Sathiyaraj and Balamurugan, 2018), and IoT based street lighting and traffic management system (Saifuzzaman, Moon and Nur, 2017).

A group of scientists at Carnegie University developed a smart traffic signal system, which was tested in Porto city. It was installed in about 450 taxis; this new system will replace the traditional traffic lights with virtual ones that appear on the windshield or the dashboard of the vehicle. Each driver will get relevant information showing how long he/she will wait at a traffic light (Abdulmunem, 2015).

An STMS has been applied in China to help the police deal with traffic offenses and accidents quickly and reduce traffic jams, which was named "City Brain." (Abigail Beall, 2018; Yi, 2017). This system detects traffic accidents within one second, which enables the police to reach the accident site within five minutes from receiving a warning. This system has achieved remarkable results in one year since its operation. The system controls traffic lights in 128 intersections, of which 100 intersections have completely dispensed the human factor. This reduced transportation time by 15.3% and saved 4.6 minutes of transportation time on highways. The system receives more than 500 warning notifications per day in the main regions, with 92% accuracy level.

Saher system regulates traffic in KSA based on a Dutch technology from Gatsometer that consists of a network of digital cameras connected to an information center. It technically verifies traffic offenses, then requests the vehicle owner's information from the database, and issues tickets

related to speeding and running traffic signals ("Saher System", 2020; "Inventor of Saher System", 2015). The Saher system achieved the highest level of traffic safety and improved the performance of traffic staff. Saher disadvantages include obstructing rescue vehicles, such as ambulances, as some drivers deliberately refrain from giving space because of fear of committing other kinds of offenses the system records. In addition, the lack of speed limit signs in some streets causes drivers to make sudden halts when they discover the cameras.

A group of researchers at the Massachusetts Institute of Technology (MIT) developed an advanced, smart system for managing traffic lights to reduce delays, improve efficiency, and reduce emissions produced by vehicles (Husni, 2015). The system collects big data from the roads and vehicles in the surrounding areas analyzed accurately to recognize traffic patterns and produce better information for traffic management. It is based on algorithms that allow the traffic prediction and the flow of vehicles on certain roads and provides the ideal procedures and periods to reduce traffic jams.

In the English city of Milton Keynes, researchers have proposed a smart traffic system in Vivacity Laboratories based on artificial intelligence, which reduces congestion on the roads ("Smart Traffic Lights", 2017). Smart traffic lights monitor speed and congestion while prioritizing traffic for ambulances with green light, in addition to relying on thermal maps to analyze how pedestrians and vehicle drivers use the roads. The project employs 2,500 sensors to control major road junctions and parking lots. The smart signals are equipped with cameras, which help determine traffic priorities for bicycles, buses, and ambulances with green lights. It is a new technology which enables traffic lights to communicate with self-driving vehicles located nearby and send warning signals while pedestrians cross the streets.

In Germany, the colors of the smart traffic lights do not change in a constant sequence and time; rather, they depend on the traffic congestion (Alkhatib, 2013). On this basis, it can prolong the time-lapse of the green color when it spots an old man who was late in crossing the street or when it detects a child carriage stumbling on the road. These smart lights operate with cameras and sensors of pressure and temperature and regulate pedestrian traffic according to the flow of vehicles and the number of pedestrians. For example, the system can extend the time of the green color from six to twelve seconds. Lasers and infrared rays are used to regulate traffic, as infrared rays detect the distance between vehicles and predict congestion. Therefore, it directs vehicle drivers through navigation devices or radio to adopt a certain speed. In contrast, laser rays alert the driver to the passage of a child or a bicycle on his/her right side when turning by emitting a warning sound.

The idea of the traffic system in Toronto is based on reducing waiting times and harmonizing traffic lights with the flow of vehicles (Hussein, 2014). The researchers were able to design smart traffic lights using the Marlin-ATSC system that reduces waiting time. It relies on game theory, artificial intelligence algorithms, and sensors. It dynamically adjusts green and red light periods according to the actual flow of traffic, saving money, reducing wasted time and carbon emission.

The Public Works Authority in Qatar announced the start of the first phase of operating an e-system that allows traffic lights to identify civil defense vehicles and ambulances to open for them automatically (Hafez, 2014). The new e-system changes the traffic lights to green when the rescue vehicles approach the selected intersection/junction with traffic signals and helps the vehicles reach the scene of the accident quickly and safely. The system consists of three main components, a vehicle-mounted control unit, a receiver unit installed at the intersections, and a central management system. Two researchers at al-Quds Open University developed a similar system for controlling traffic lights in emergencies through emergency vehicles via mobile phones ("Entrepreneur Stories", 2014). A device that controls the traffic lights was developed by a control message sent by the emergency vehicle driver to a specific mobile number that identifies the traffic light via a GSM module fixed on it. In emergencies, the ordinary traffic system is replaced with the emergency system until the emergency is finished.

In the Palestinian context, the Judge and chairperson of the Ramallah Court of First Instance stated that the weekly average of traffic cases in Ramallah is about 1,000 offenses per

session, that is, an average of 8000 traffic offenses per month since the court holds eight sessions per month. The Judge clarified that there is a huge number of traffic offenses, and the process of tracking them takes a lot of effort from the court and the related authorities in terms of detection, retrieval, recording judgments, organizing judgment summaries, and transferring them to the Public Prosecution, in order to be executed by the police (Shasha News, 2014).

The previous studies show that most of the previous TMSs focus on traffic flow management and congestion control, while none mentioned traffic offense detection, which is the major reason for traffic congestion and accidents. This paper sets out a radical change in transport and traffic management systems in Palestine. In addition to traffic monitoring and control, our proposed STMS deals with traffic offenses that include prevention, detection, recording, ticket issuance, and execution.

PROBLEM STATEMENT

The research problem lies in the risks and losses resulting from traffic congestion and the consequent offenses committed by drivers of different vehicles, which the traditional traffic management system cannot detect; in case there were no traffic police present at the corresponding moment. The shortcomings of the traditional system to detect traffic offenses cause accidents and losses in lives, public and private properties. This situation increases the financial burden on the state treasury in treating the injured and repairing the resulting property damages or losses, in addition to losing the ticket fees of the undiscovered offenses. Moreover, results of the qualitative and quantitative instruments of this research emphasize the importance of developing our proposed system, where the participants insisted that the Palestinian cities need to develop an STMS that uses cameras, sensors, and radars, to ensure the application and transparency of the traffic law, referring that traffic offenses are the major reason for traffic accidents. However, this requires suitable infrastructure and a sufficient allocated budget. They also suggested that the STMS should be able to inform the vehicle owners of any offenses that occurred while driving their vehicles by the others in order to take the needed precautions. Finally, they called to evaluate the relevance of the offense fines to the nature of the offenses and applying suitable penalties. In its annual statistical report, the Ministry of Transportation (2020) reported that the traffic police issued 231363 traffic offenses in 2019, with an increase of 10079 above 2018, 25% of which in Nablus district, 21% in Ramallah, and 18% in Hebron. Moreover, the number of traffic accidents due to traffic offenses reached 13165 accidents, causing 10846 injuries and 126 death. Most of these accidents occurred in Ramallah with 27% and Nablus with 20%. Therefore, the proposed STMS comes to address the described issues related to traffic congestion and offenses that would cause material damage and heavy losses amounting to the losses of human lives or that may cause permanent or temporary disabilities.

DESIGN AND IMPLEMENTATION OF THE STMS

The researcher developed a prototype for the proposed STMS following the system development lifecycle in four phases: analysis, design, implementation, and testing. The system analysis was based on a survey that consists of a personal interview and a questionnaire for a sample of the target audience, which focused on the vehicle drivers.

System Analysis and Requirements

The system's requirements and needs assessment were based on a survey, which shows the lack of a smart traffic system and unjust application of the traffic laws. In addition, police presence on the roads on a regular basis contributes to reducing traffic offenses, but drivers change routes to bypass the police. Moreover, results reveal the lack of sufficient awareness among the relevant authorities on traffic laws and systems, the penalties imposed on the drivers are not deterrent, and they tend to deny offenses by providing false excuses. Finally, traffic offenses are the major cause of traffic accidents and congestion, and the current traffic system is not so efficient to deal with these issues. Therefore, a traffic management solution is needed to reduce traffic offenses and accidents, prevent using illegal vehicles and issue penalties for traffic offenders by implementing an advanced TMS that uses cameras to detect traffic offenses automatically. This will promote transparency and integrity by enacting laws related to pleas in courts since drivers

disagreed on the relevance of the fines to the nature of the offenses. They suggested re-evaluating the relevance of the offense fines and applying stricter penalties. They emphasized developing a smarter system that uses cameras, sensors, and radars for auto-detection of traffic offenses. Moreover, results, which will be elaborated in subsection 5.2, yield that 95% of the offense penalties were based on fines, and 24% of the drivers were totally unconvinced that they deserved the traffic offenses issued in 2019. Moreover, 32% of the drivers caused 1-2 traffic accidents, where 68% of these accidents (68%) were due to traffic offenses, causing physical and material damages, as well as losses in people's lives and public properties. The number of traffic offenses steadily increased among drivers who usually drive for more than three hours per day, mainly due to fatigue or zoning out. In addition, there was a significant relationship between the number of traffic tickets and accidents. Therefore, the proposed solution should overcome the mentioned issues to support the traffic authorities to control traffic offenses.

The STMS Design

Figure 1 shows the block diagram of the proposed STMS, where a central processing unit controls all operations, receives data from the sensors and cameras, analyzes it, and issues the appropriate commands when a traffic offense occurs. The system consists of three main units; the Traffic Management and Congestion Control Unit (TMCCU) is the central unit responsible for system management and decision making when a traffic offense is detected. It receives offense information from a Traffic Monitoring Unit (TMU) related to the detected traffic states and offenses. When a driver commits a traffic offense, the Vehicle Identification Unit (VIDU) identifies the vehicle's ID using image processing or extracts it from the vehicle's memory. It can identify its driver's ID through a query to the Traffic Offense Recording Unit (TORU), which in turn records the offense, issue an e-ticket, and sends it to the driver's phone using a messaging server.

The TMU consists of cameras and sensor modules, as shown in Figure 2. The traffic sensor module is connected to the Raspberry Pi main processing unit via an Arduino controller. It monitors the roads and junctions where a sensor control triggers the relevant sensor on some events to collect data from the laser, speed, or magnetic sensor. The TORU block chart is depicted in Figure 3. It connects the main processing unit to the centralized police database and the messaging server, when necessary, via a secure link to the Internet through a connection module (e.g., Ethernet or 3G/4G). It responds to queries regarding vehicles and drivers, records offenses, issues e-tickets, and sends them to the drivers. Figure 4 illustrates the VIDU, which is based on RFID technology and positioned between the TMCCU and the TMU. In addition, the vehicle's ID controller consists of NRF 2.4GHz, RF 433MHz, and RFID modules. It connects the road/vehicle sensors to the main processing unit. Different RF modules are used for different distances between communicating devices; for example, we need to connect all Arduinos to all traffic lights at a junction for synchronization issues. Moreover, the RF433MHz is used for a short distance to prevent interference between different transmitters of vehicles and the receiver of each lane. In addition, nRF2.4 can be used for over-speeding offenses as described below. As shown in Figure 5, the TMU is responsible for traffic offense detection. It is connected to the Raspberry Pi processing unit that enables both camera and laser sensor modules. These modules collect data related to traffic offenses. The TMU is integrated with the VIDU that recognizes offending vehicles either via pairing with the vehicle's transmitter or via character recognition of the vehicle's plate number.

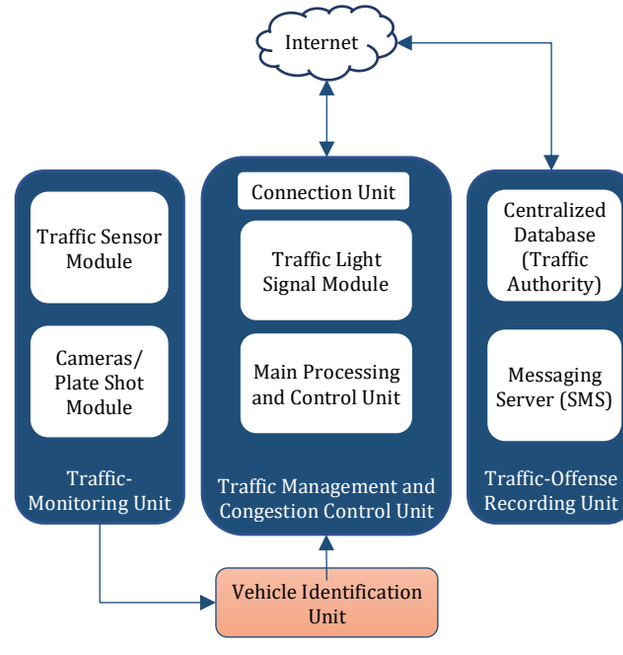

Figure 1 Block Diagram of the Proposed STMS

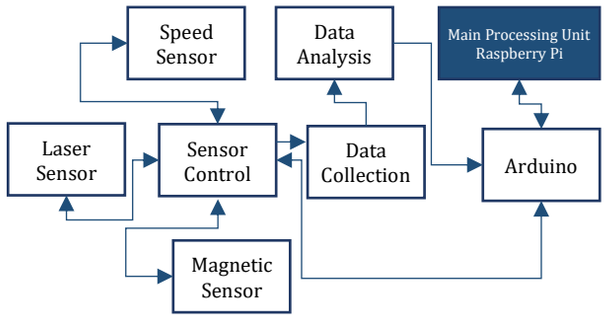

Figure 2 Traffic-Sensor Module

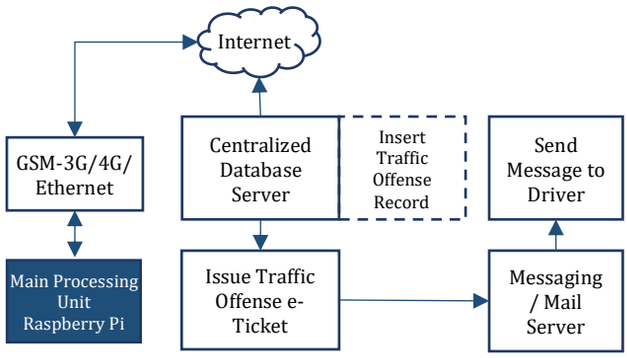

Figure 3 Traffic-Offense Recording Unit

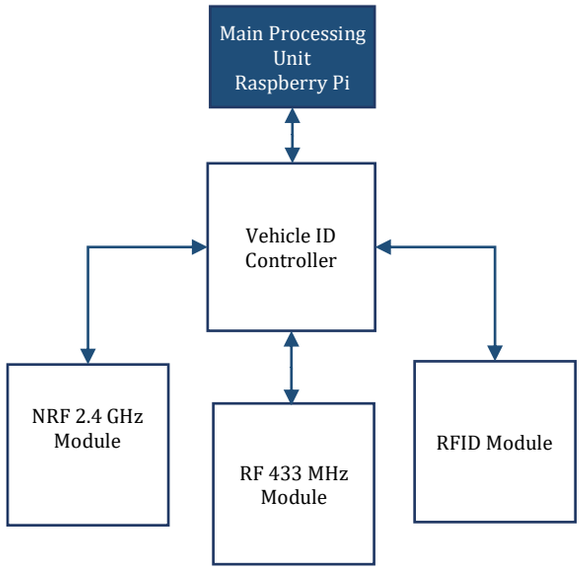

Figure 4 Vehicle ID Unit (RF Module)

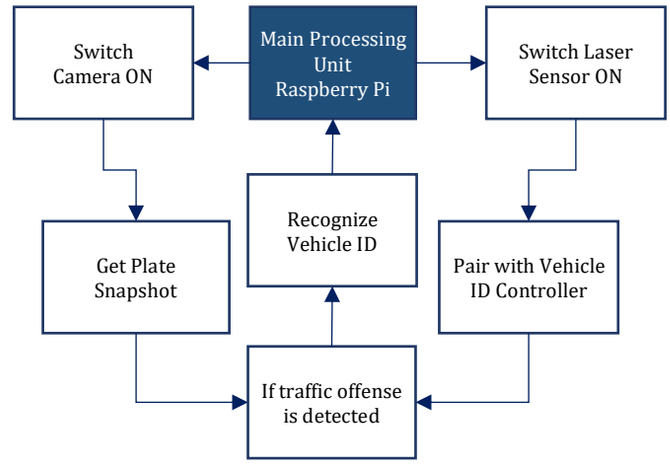

Figure 5 Traffic Monitoring Unit (Traffic-Offense Detection)

For the over-speeding offense, a vehicle speed sensor and a GPRS are embedded on the vehicle to detect its speed compared with the speed limit of that location. When it exceeds the speed limit, a query is sent to the database to identify its owner /driver, and the system issues an e-ticket indicating the speed limit, the speed of the vehicle, and the vehicle's information; it then sends a notification to the driver and the competent authorities. However, for privacy concerns, an inexpensive alternative solution can be based on nRF2.4, where a transmitter in the vehicle connects to the nearest receiver installed on the road (e.g., every 2km), maintaining the coordinates of each receiver on the central database. The speed limit can be obtained from a memory attached to each receiver. For prohibited parking, the STMS employs a QR code reader embedded in the vehicle that extracts information from a QR code on the prohibited parking sidewalk and operates in the same procedure above. The e-ticket indicates the location and description of the offense, such as a red-white sidewalk or a pedestrian crossing.

The centralized police database of the proposed STMS consists of six entities with vehicle ID as the primary key. The first entity identifies the vehicles with three attributes (license number, brand and description). Another entity identifies the geographical distribution of the Arduino controllers and their status (e.g., whether they are functioning or not) with four attributes (vehicle license number, driver ID, Arduino ID, and status). The third identifies the driver through (driver name, ID, driving license type, effective

and expiry dates, mobile number, and e-mail). The fourth entity identifies traffic offenses to be recorded when they occur with eight attributes (driver and vehicle IDs, offense number, date and time, fine payment due, and initial/final amounts, as well as notes). Finally, two more entities identify vehicle license type and traffic offense type.

EXPERIMENT SETUP

Figure 6 shows a block diagram of the prototype of our proposed STMS related to running red signals, which provides a testing and experiment setup. When the traffic light becomes red, the sensors or cameras turn on and recognize the ID (e.g., the plate number) of the vehicle committing a traffic offense. The researcher used image processing openALPR[1] open-source library to recognize the plate number. In turn, the system sends a query via a secure communication link through the Internet to a central database of the traffic police, inquiring the mobile phone number of the owner and/or the driver of the vehicle. Then, the system records a traffic offense, issues an e-ticket, and sends it immediately to the offender's mobile phone, specifying the offense location, time, and fine amount. The same procedure is applied to other traffic offenses with some modifications depending on the offense type and requirements. The prototype consists of four modules:

1. The vehicle's transmitter (e.g., TX RF 433MHz) that contains its ID (i.e., plate number).
2. The road's receiver (e.g. RX RF 433MHz), which is fixed on the junctions.
3. The internet connection module, which connects to the central database via an Ethernet or GSM 3G/4G shields.
4. The main processing unit using Raspberry Pi with a Pi Camera.

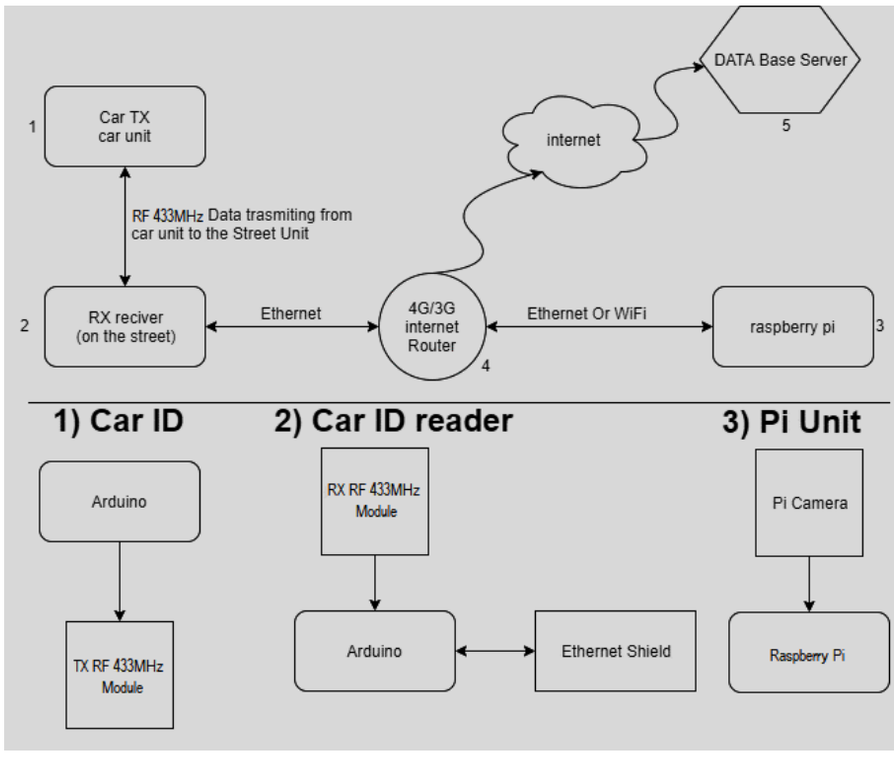

Figure 6 The Case of Running Red Light Offense Detection using Pi Camera.

When the traffic signal is red, and the vehicle passes over the RX RF 433 MHz receiver module installed underground on each lane and connected to the Arduino, the TX RF 433MHz transmitter installed inside the vehicle sends the vehicle's ID to the receiver. Then, the Arduino creates a TCP connection with the Raspberry Pi through the

[1] GitHub. Retrieved 2012, February 21 from https://github.com/openalpr/openalpr.git

Internet connection module and sends the information to it, so the Raspberry Pi turns on the camera and captures the image of the offending vehicle. Accordingly, the Raspberry Pi creates another connection to the database server through a VPN connection to store the traffic offense data, including a timestamp, the vehicle's ID, and image while crossing the red signal and the offense penalty. The server issues an e-ticket, executes a query to extract the driver's phone number and sends the e-ticket to him in a text message via an SMS server.

RESULTS AND DISCUSSION

This section shows the system testing results through practical experiments on the prototype for the case of running a red light. In addition, it covers the results of the survey based on the quantitative instrument (e.g., the questionnaire). It also provides an in-depth discussion of the results.

THE STMS TESTING RESULTS

In order to prove the concept and to test the proposed STMS, the researcher conducted two experiments on the prototype since it was prohibited to fix it on a real traffic light, and the production of a real system requires more funds and sophisticated hardware and software. At a fixed speed of 70km/hour, we measured the response time and distance, the number of recorded traffic offenses (i.e., issued tickets), the number of received tickets through messages, and the offense-detection accuracy for a sample of 100 trials. The experiments were repeated five times at different timings (Morning, Afternoon, Evening, Night, and Late Night) and weather conditions (e.g., Sunny and Rainy). The results are averaged and summarized in Tables 1 and 2.

Table 1. Results of the Experiment in Sunny Weather

Timing	Avg. Response Time (s)	Avg. Response Distance (m)	Speed (Km/Hr.)	Recorded Traffic Offenses	No. of Received Messages	Offense-Detection Accuracy (%)
Morning	0.50	09.7	70	95	92	95
Afternoon	0.45	08.8	70	93	85	93
Evening	0.50	09.7	70	89	80	89
Night	0.58	11.3	70	78	75	78
Late Night	0.56	10.9	70	75	71	75
Average	0.52	10.1	70	86	80.6	86

Table 2. Results of the Experiment in Rainy Weather

Timing	Avg. Response Time (s)	Avg. Response Distance (m)	Avg. Speed (Km/Hr.)	Recorded Traffic Offenses	No. of Received Messages	Offense-Detection Accuracy (%)
Morning	0.52	10.1	70	85	79	85
Afternoon	0.47	09.1	70	78	65	78
Evening	0.55	10.7	70	77	66	77
Night	0.60	11.7	70	65	62	65
Late Night	0.59	11.5	70	66	60	66
Average	0.55	10.6	70	74.2	66.4	74.2

The results show that the average accuracy of traffic-offense detection ranged between 74.2% and 84%, the average response time ranged between 0.52 and 0.55 seconds, the average response distance ranged between 10.08 and 10.62 meters, and the average number of received messages at the offender's mobile phone ranged between 66.4 and 80.6. It is clear that the performance is better for sunny weather and day than for rainy weather and night respectively. Since the other two offenses related to over-speeding and prohibited stop areas are designed on the same concept, the results of these experiments can be generalized to these offenses that will be implemented and tested in future work and studies.

SURVEY RESULTS

This subsection provides the results of the survey conducted with the target group of vehicle drivers that provided the specifications of the proposed system. Table 3 illustrates the distribution of the sample according to the gender variable, which indicates that males are dominant with a percentage of 96.4%, compared to 3.6% females.

Table 3. Distribution of the sample according to the gender

Gender	Frequency	Percentage	Actual Percentage	Cumulative Percentage
Males	108	96.4	96.4	96.4
Females	4	3.6	3.6	100.0
Total	112	100.0	100.0	

Table 4 depicts the distribution of the sample according to the age variable, where the percentage was 5.4% for those aged 20 years and under, 42.9% for those between the ages of 21-30, 23.2% for those aged 31-40, and 11.6% for those aged 50 years and over.

Table 4. Distribution of the sample according to the Age Group

Age Group	Frequency	Percentage	Actual Percentage	Cumulative Percentage
Below 20	6	5.4	5.4	5.4
21-30	48	42.9	42.9	48.2
31-40	26	23.2	23.2	71.4
41-50	19	17.0	17.0	88.4
More than 50	13	11.6	11.6	100.0
Total	112	100.0	100.0	

Table 5 indicates the distribution of the sample according to the educational level variable. Results showed that the percentage was 30.4% for those below high school, 25.0% for those who passed high school, and with regard to the intermediate diploma, the percentage was 3.6%, while 37.5% of the sample has a bachelor's degree, and 3.6% of the sample have postgraduate studies.

Table 5. Distribution of the sample according to the Level of Education

Level of Education	Frequency	Percentage	Actual Percentage	Cumulative Percentage
Below high school	34	30.4	30.4	30.4
High school	28	25.0	25.0	55.4
Intermediate diploma	4	3.6	3.6	58.9
Bachelor's degree	42	37.5	37.5	96.4
Postgraduate studies	4	3.6	3.6	100.0
Total	112	100.0	100.0	

In addition, figures 7-12 summarize the distribution of the sample on other variables. In summary, most of the participants were males aged 21-30 years old, below high school, or who had a bachelor's degree. The driver's profession was mostly divided between public and private transportation at 38% and 37%, respectively.

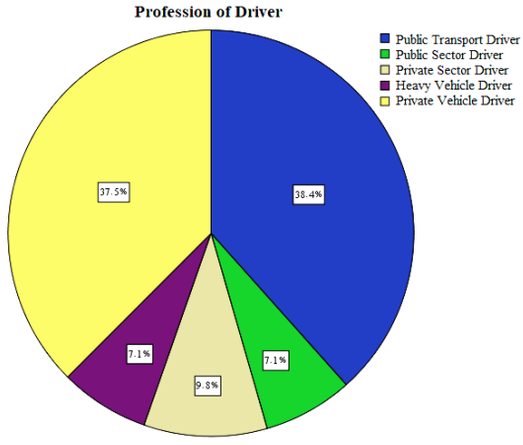

Figure 7 Profession of Driver

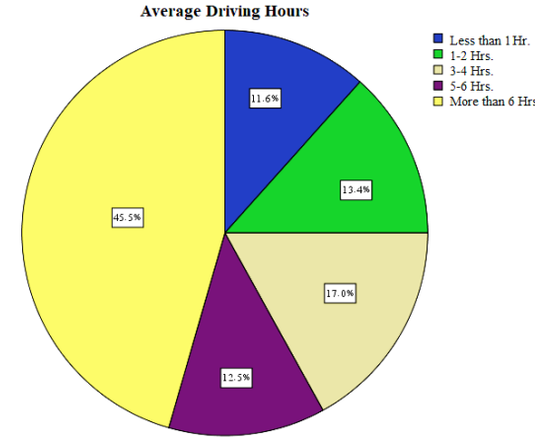

Figure 8 Average Driving Hours

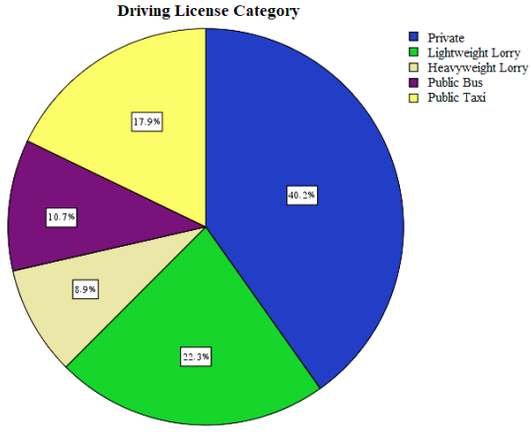

Figure 9 Driving License Category

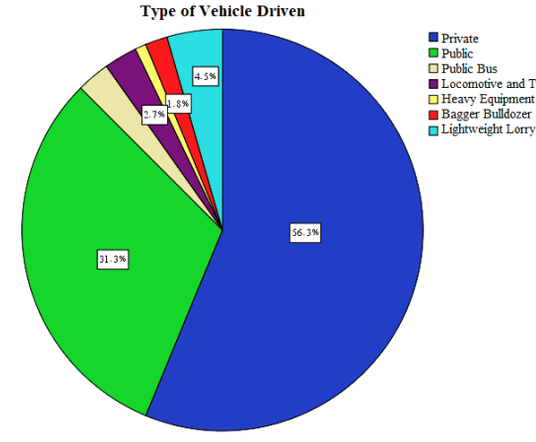

Figure 10 Type of Vehicle Driven

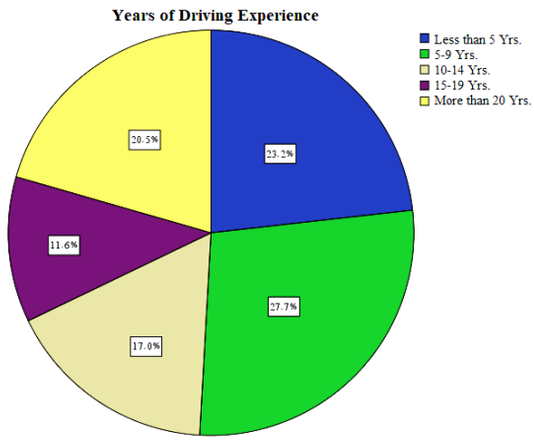

Figure 11 Years of Driving Experience

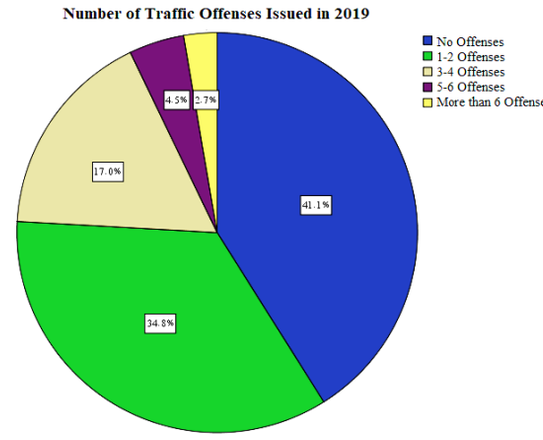

Figure 12 Number of Traffic Offenses Issued in 2019

The average daily driving hours were more than 6 hours for 45% of the sample, and the driving license category was mostly for private vehicles with 40%. Moreover, the vehicle type was mostly private (56%) or public (31%), and the driving experience was ranged 5-9 years (28%) and almost the same for drivers with less than 5 years (23%) or more than 20 years of experience (21%). However, 41% of the sample were not issued any traffic tickets in 2019, 35% were issued 1-2 tickets, and 17% of the drivers were issued 3-4 traffic-offense tickets.

Figures 13-18 indicate the distribution of the sample according to the following variables:

- The drivers are convinced that they deserved the issued traffic tickets: 57.6% were 'totally convinced', compared to 24% who were 'totally unconvinced'.
- Nature of Penalties: most of the penalties (95%) were based on fines.
- The appropriateness of the penalties against the traffic offenses: 58% were totally convinced with the penalties, against 29% who were totally unconvinced with them.
- Number of traffic accidents in 2019: 66% of the drivers did not cause any traffic accident, while 32% caused 1-2 traffic accidents.
- Causes of traffic accidents: 68% of the accidents were due to traffic offenses. Tables 6 provides more details on the causes of these accidents.
- The nature of the damages resulting from traffic accidents: 60% of them were material damages, 16% were physical and material damages, 13% were in material and public properties, and 8% were in physical, material, and public properties.

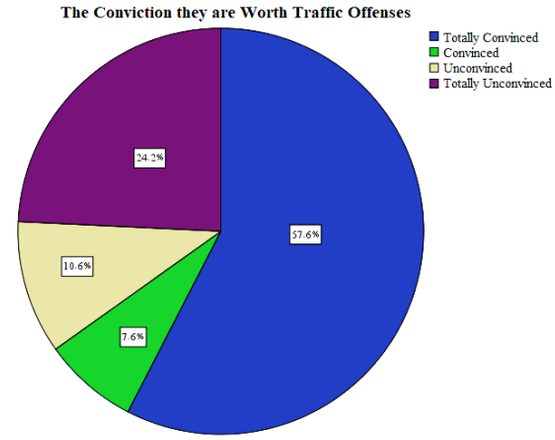

Figure 13 The Conviction they are Worth Traffic Offenses

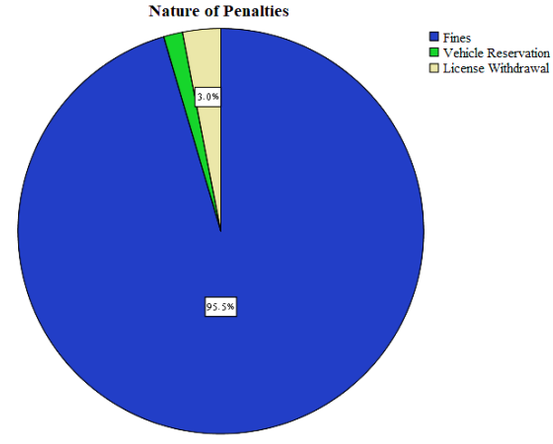

Figure 14 Nature of Penalties

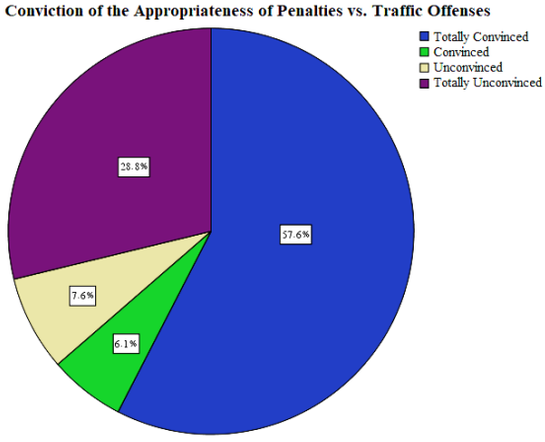

Figure 15 The Extent of Conviction of the Appropriateness of the Penalties vs. the Traffic Offenses

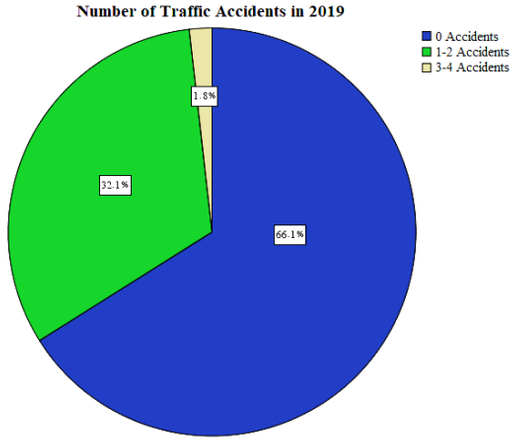

Figure 16 Number of Traffic Accidents in 2019

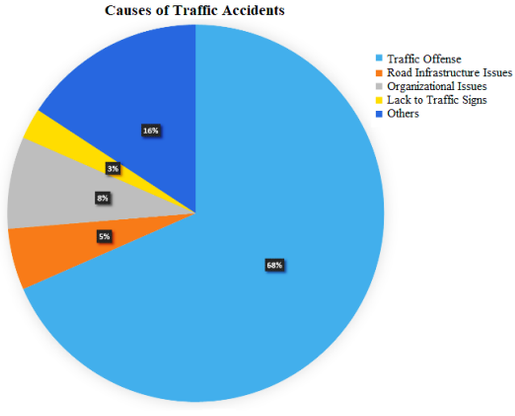

Figure 17 Causes of Traffic Accidents

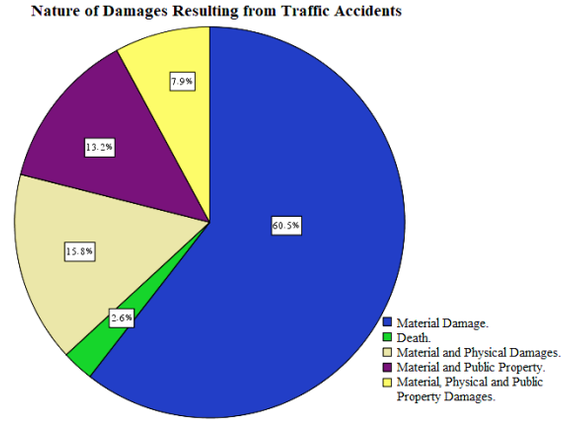

Figure 18 The Nature of Damages Resulting from Traffic Accidents

Table 6. Causes of Accidents (Unifying Traffic Offenses)

Causes of Accidents, If any	Frequency	Percentage	Actual Percentage	Cumulative Percentage
Traffic tickets	26	23.2	68.4	68.4
Problems in the road infrastructure	2	1.8	5.3	73.7
Traffic regulation problems	3	2.7	7.9	81.6
Lack of traffic signs	1	0.9	2.6	84.2
Others	6	5.4	15.8	100.0
Total	38	33.9	100.0	
No accidents	74	66.1		
Total	112	100.0		

Detailed results of data analysis are listed in Appendix A (Tables 7-41). In summary, these tables show the results of the relationship between the traffic offenses tickets and traffic accidents variables, as well as the relationship between these two variables and the variables of gender, age group, educational level, profession, average daily driving hours, driving license category, type of the vehicle, and years of driving. It is noted that the significance level for all the variables is greater than 0.05. Thus, the relationship is not statistically significant. Therefore, the null hypothesis is valid; i.e., there is no relationship, except for three variables, as described below.

The first case is shown in Tables 24 and 25. Table 24 illustrates the distribution of the number of traffic tickets issued in 2019 on the average daily-driving hours. It shows that 2.6% of those who received 1-2 traffic tickets during the year 2019 drove for less than one hour on average. The same holds for members whose daily driving hours ranged between 1-2 hours. On the other hand, both tables revealed a steady increase in the number of offenses among individuals who drive more than 3 hours per day. Based on the Pearson correlation coefficient analysis in Table 25, it was found that the value of the significance level of 0.002 is less than 0.05. Therefore, the null hypothesis is

rejected, and we accept the alternative hypothesis; the relationship is statistically significant between the number of tickets issued during 2019 and the average daily driving hours. That is, an increase in the rate of daily driving hours leads to an increase in the number of traffic accidents. This could be attributed to the higher possibility of accidents due to the long driving hours or could be due to fatigue or zoning out during the long periods of driving.

The second case is shown in Tables 28 and 29, where the significance level equals 0.05, indicating a statistically significant relationship between the number of traffic tickets in 2019 and the driving license category. Most of the traffic tickets were issued, alternately, in 2019 for holders of private vehicle licenses and public service vehicle licenses.

The third case is shown in Tables 40 and 41, where there is a statistically significant relationship between the number of traffic tickets issued for the study sample in 2019 and the number of traffic accidents committed by them in the same year, with a significance level of 0.032, i.e., less than 0.05, so the null hypothesis is rejected.

CONCLUSIONS AND RECOMMENDATIONS

This research objective has been achieved, and the concept has been proved. The proposed STMS was designed for three traffic offenses, running a red light, speeding, and parking in a prohibited parking space. In order to prove its importance and feasibility, the researcher conducted a survey using both quantitative and qualitative instruments. Results of both instruments show that the implementing proposed STMS is highly urgent to manage traffic congestion and accidents through monitoring and detection of traffic offenses in a smart way.

The researcher implemented and tested the first traffic offense in a testing environment designed for this purpose, including different times in the day and weather conditions. The proposed STMS proved an acceptable accuracy of traffic offense detection, which ranges between 74%-84% with different weather conditions.

However, in light of the obtained results and discussion, the researcher concludes the following recommendations for the traffic authorities:

1. They should apply stricter laws against those committing traffic offenses and balance between the financial penalty and the nature of a traffic offense.
2. They are required to develop a similar integrated STMS that uses cameras, sensors, and radars to ensure the traffic laws' application and transparency.
3. They should develop the road's infrastructure accordingly and take into consideration the required substantial budget.
4. They should utilize the proposed STMS and its valuable features, e.g., it can inform the vehicle owner of any traffic offense that occurred while driving his/her vehicle by other people.

ACKNOWLEDGEMENT

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Appendix A

Detailed Results of the Quantitative Instrument

Table 7 depicts the causes of traffic accidents, including the traffic offenses committed by drivers of the study sample.

Table 7. Causes of Accidents (With Details of Traffic Offenses)

Causes of Accidents, If Any	Frequency	Percentage	Actual Percentage	Cumulative Percentage
Traffic ticket	13	11.6	34.2	34.2
Problems in the road infrastructure	2	1.8	5.3	39.5
Traffic regulation problems	3	2.7	7.9	47.4
Lack of traffic signs	1	.9	2.6	50.0
Traffic tickets, speeding	11	9.8	29.0	79.0
Traffic tickets, seat belts	2	1.8	5.3	84.3
Others	6	5.4	15.8	100.0
Total	38	33.9	100.0	
No accidents	74	66.1		
Total	112	100.0		

The data in Table 8 refers to the distribution of the study sample according to the relationship between the number of traffic offenses issued in 2019 and the gender variables. The results showed that 91.3% of the study sample individuals who did not receive tickets were males compared to 8.7% of females. However, we found that all of the individuals who committed traffic offenses were males regardless of the number of offenses.

Table 8. Relationship between the Number of Traffic Offenses Issued in 2019 and Gender

Gender	Number of Traffic Offenses Received in 2019					Total
	None	1-2	3-4	5-6	More than 6	
Males	91.3%	100.0%	100.0%	100.0%	100.0%	96.4%
Females	8.7%					3.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Based on the Chi-square test (Pearson correlation coefficient) in Table 9, the value of the significance level is 0.203 that is greater than 0.05; thus, it is not statistically significant. Accordingly, we accept the null hypothesis that there is no relationship between the variable of the number of traffic offenses issued in 2019 and the gender variable.

Table 9. Correlation between the Number of Traffic Offenses and Gender Variables (Chi-Square Test)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.952a	4	.203
Likelihood Ratio	7.333	4	.119
Linear-by-Linear Association	3.563	1	.059
N of Cases	112		

a. 7 cells (70.0%) have an expected count of less than 5. The minimum expected count is 11.

The data in Table 10 refers to the distribution of the study sample according to the relationship between the number of accidents in 2019 and the gender variables. It is noted that 94.6% of the study sample, who were not involved in accidents, were males, while 5.4% were females. It is also noted that all of the study sample's members, who had traffic accidents, were all males, regardless of the number of accidents in which they were involved.

Table 10. Relationship between the Number of Accidents and Gender

Gender	Number of Traffic Accidents in 2019			Total
	None	1-2	3-4	
Male	94.6%	100.0%	100.0%	96.4%
Female	5.4%			3.6%
Total	100.0%	100.0%	100.0%	100.0%

According to Table 11, the value of the significance level of 0.345 is greater than 0.05. Thus, it is not statistically significant. Therefore, the null hypothesis here is valid; there is no correlation between the number of accidents in 2019 and the gender variables.

Table 11. Correlation between the Number of Accidents and Gender Variables

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.130[a]	2	.345
Likelihood Ratio	3.391	2	.183
Linear-by-Linear Association	1.976	1	.160
N of Cases	112		

a. 4 cells (66.7%) have an expected count of less than 5. The minimum expected count is .07.

The data in Table 12 refers to the distribution of the study sample according to the relationship between the number of traffic offenses in 2019 and the age group variables. It is noted that 43.5% of the age group (21-30 years) did not commit any traffic offenses (the highest percentage among the study sample). On the other hand, only 6.5% of the age group (20 years and below) did not commit any traffic offenses (the lowest percentage among the study sample). However, it was

revealed that the highest percentages of traffic offenders are from the age group between 21-30 years, regardless of the number of offenses. On the other hand, the lowest percentages of traffic offenders are from the age group of 50 years and above (1-2 offenses), while those between 41-50 years committed 3-4 offenses and 6-5 offenses, and finally, the age group (50 years and above) had more than 6 offenses.

Table 12. The Relationship between the Traffic Offense Tickets Received in 2019 and the Age Group

Age Group	Number of Traffic Tickets Received in 2019					Total
	None	1-2	3-4	5-6	More than 6	
20 and below	6.5%	7.7%				5.4%
21-30	43.5%	43.6%	31.6%	60.0%	66.7%	42.9%
31-40	26.1%	23.1%	26.3%			23.2%
41-50	13.0%	20.5%	15.8%	40.0%		17.0%
50 and above	10.9%	5.1%	26.3%		33.3%	11.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

According to Table 13, it was found that the value of the significance level of 0.529 is greater than 0.05. Thus, it is not statistically significant. Therefore, the null hypothesis here is valid; there is no relationship between the number of offenses issued in 2019 and the age group variables.

Table 13. The Correlation between the Number of Offenses Received in 2019 and the Age Group Variables.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.941a	16	.529
Likelihood Ratio	17.829	16	.334
Linear-by-Linear Association	1.371	1	.242
No of Cases	112		

a. 17 cells (68.0%) have an expected count of less than 5. The minimum expected count is .16.

The data in Table 14 refers to the distribution of the study sample according to the relationship between the number of accidents in 2019 and the age group. It is noted that 40.5% of the age group (21-30 years) did not have any accident (the highest percentage), while 5.4% of the age group (20 and below) did not have any accident (the lowest percentage). On the other hand, 44.4% (the highest percentage) of those who had accidents in 2019 were from the age group (21-30) with (1-2 accidents). The age groups 20 years and below and 41-50 years had the lowest rate of accidents. Most of the accidents occurred among the age group of 21-30 years with 3-4 accidents.

Table 14. Relationship between the Number of Accidents in 2019 and the Age Group Variable

Age group	Number of Accidents in 2019			Total
	None	1-2	3-4	
20 and below	5.4%	5.6%		5.4%
21-30	40.5%	44.4%	100.0%	42.9%
31-40	20.3%	30.6%		23.2%
41-50	23.0%	5.6%		17.0%
50 and above	10.8%	13.9%		11.6%
Total	100.0%	100.0%	100.0%	100.0%

According to Table 15, it was found that the value of the significance level of 0.392 is greater than 0.05. Thus, it is not statistically significant. Therefore, we accept the null hypothesis; there is no relationship between the number of accidents in 2019 and the age group variables.

Table 15. The Correlation between the Number of Accidents and the Age Group Variables.

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	8.434a	8	.392
Likelihood Ratio	9.914	8	.271
Linear-by-Linear Association	1.169	1	.280
No of Cases	112		

a. 8 cells (53.3%) have an expected count of less than 5. The minimum expected count is .11.

Table 16. Relationship between the Number of Received Traffic Tickets in 2019 and the Academic Qualification.

Academic Qualifications	Number of Traffic Tickets You Received in 2019					Total
	None	1-2	3-4	5-6	More than 6	
School Dropout	23.9%	33.3%	42.1%	20.0%	33.3%	30.4%
High School Diploma	23.9%	23.1%	31.6%	20.0%	33.3%	25.0%
Intermediate Diploma	6.5%			20.0%		3.6%
Bachelor	39.1%	41.0%	26.3%	40.0%	33.3%	37.5%
Postgraduate	6.5%	2.6%				3.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 17. Correlation between the Number of Traffic Tickets and the Academic Qualifications)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.426a	16	.714
Likelihood Ratio	13.180	16	.660
Linear-by-Linear Association	1.824	1	.177
N of Cases	112		

a. 17 cells (68.0%) have an expected count of less than 5. The minimum expected count is .11.

Table 18. Relationship between the Number of Traffic Accidents in 2019 and the Academic Qualification

Academic Qualification	Number of Traffic Accidents You Had in 2019			Total
	None	1-2	3-4	
School Dropout	33.8%	25.0%		30.4%
High School Diploma	24.3%	25.0%	50.0%	25.0%
Intermediate Diploma	1.4%	8.3%		3.6%
Bachelor	36.5%	38.9%	50.0%	37.5%
Postgraduate	4.1%	2.8%		3.6%
Total	100.0%	100.0%	100.0%	100.0%

Table 19. Correlation between the Number of Accidents and the Academic Qualifications)

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	5.431a	8	.711
Likelihood Ratio	5.765	8	.674
Linear-by-Linear Association	.542	1	.462
No of Cases	112		

a. 9 cells (60.0%) have an expected count of less than 5. The minimum expected count is .07.

Table 20. Relationship between the Number of Traffic Tickets Issued in 2019 and the Profession of the Driver

Profession	Number of Traffic Tickets You Received in 2019					Total
	None	1-2	3-4	5-6	More than 6	
Public Transport Driver	23.9%	33.3%	78.9%	60.0%	33.3%	38.4%
Public Sector Driver	10.9%	7.7%				7.1%
Private Sector Driver	8.7%	12.8%	5.3%	20.0%		9.8%
Heavy Equipment Driver	8.7%	10.3%				7.1%
Private car Driver	47.8%	35.9%	15.8%	20.0%	66.7%	37.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 21. Correlation between the Number of Traffic Tickets and the Profession of the Driver

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	23.444a	16	.102
Likelihood Ratio	26.244	16	.051
Linear-by-Linear Association	6.219	1	.013
No of Cases	112		

a. 19 cells (76.0%) have an expected count of less than 5. The minimum expected count is .21

Table 22. Relationship between the Number of Accidents in 2019 and Profession of the Driver

Academic Qualification	Number of Traffic Accidents in 2019			Total
	None	1-2	3-4	
Public Transport Driver	36.5%	44.4%		38.4%
Public Sector Driver	8.1%	5.6%		7.1%
Private Sector Driver	12.2%	5.6%		9.8%
Heavy Equipment Driver	8.1%	2.8%	50.0%	7.1%
Private car Driver	35.1%	41.7%	50.0%	37.5%
Total	100.0%	100.0%	100.0%	100.0%

Table 23. Correlation between the Number of Traffic Accidents and the Profession of the Driver

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.384a	8	.311
Likelihood Ratio	7.891	8	.444
Linear-by-Linear Association	.145	1	.704
No of Cases	112		

a. 8 cells (53.3%) have an expected count of less than 5. The minimum expected count is .14

Table 24. Relationship between the Number of Traffic Tickets in 2019 and the Average Daily Driving Hours

Average Daily Driving Hours	Number of Traffic Tickets You Received in 2019					Total
	None	1-2	3-4	5-6	More than 6	
Less than one hour	23.9%	2.6%			33.3%	11.6%
1-2 hours	26.1%	2.6%	5.3%	20.0%		13.4%
3-4 hours	13.0%	28.2%	5.3%	20.0%		17.0%
5-6 hours	6.5%	15.4%	15.8%	20.0%	33.3%	12.5%
More than 6 hours	30.4%	51.3%	73.7%	40.0%	33.3%	45.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 25. Correlation between the No. of Traffic Tickets and the Average Daily Driving Hours

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	37.628a	16	.002
Likelihood Ratio	41.337	16	.000
Linear-by-Linear Association	10.336	1	.001
No of Cases	112		

a. 16 cells (64.0%) have an expected count of less than 5. The minimum expected count is .35.

Table 26. Relationship between the Number of Accidents in 2019 and the Average Daily Driving Hours

Average Daily Driving Hours	Number of Traffic Accidents in 2019			Total
	None	1-2	3-4	
Less than one hour	16.2%	2.8%		11.6%
1-2 hours	13.5%	11.1%	50.0%	13.4%
3-4 hours	17.6%	16.7%		17.0%
5-6 hours	9.5%	16.7%	50.0%	12.5%
More than 6 hours	43.2%	52.8%		45.5%
Total	100.0%	100.0%	100.0%	100.0%

Table 27. Correlation between the Number of Accidents and the Average Daily Driving Hours

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.211a	8	.190
Likelihood Ratio	11.807	8	.160
Linear-by-Linear Association	2.001	1	.157
N of Cases	112		

a. 8 cells (53.3%) have an expected count of less than 5. The minimum expected count is .23.

Table 28. Relationship between the Number of Traffic Tickets Received in 2019 and the License Category.

License Category	Number of Traffic Tickets Received in 2019					Total
	None	1-2	3-4	5-6	More than 6	
Private	47.8%	41.0%	21.1%	20.0%	66.7%	40.2%
light truck	28.3%	17.9%	10.5%	40.0%	33.3%	22.3%
Heavy truck	10.9%	12.8%				8.9%
Public bus	6.5%	10.3%	21.1%	20.0%		10.7%
Taxi	6.5%	17.9%	47.4%	20.0%		17.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 29. Correlation between the Number of Received Traffic Tickets and License Category)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	26.318a	16	.050
Likelihood Ratio	27.728	16	.034
Linear-by-Linear Association	6.014	1	.014
N of Cases	112		

a. 18 cells (72.0%) have an expected count of less than 5. The minimum expected count is .27.

Table 30. Relationship between the Number of Accidents and the License Category

License Category	Number of Traffic Accidents You Had in 2019			Total
	None	1-2	3-4	
Private	40.5%	38.9%	50.0%	40.2%
light truck	24.3%	19.4%		22.3%
Heavy truck	10.8%	2.8%	50.0%	8.9%
Public bus	9.5%	13.9%		10.7%
Taxi	14.9%	25.0%		17.9%
Total	100.0%	100.0%	100.0%	100.0%

Table 31. Correlation between the Number of Accidents and the License Category)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.794a	8	.360
Likelihood Ratio	8.267	8	.408
Linear-by-Linear Association	.686	1	.408
No of Cases	112		

a. 7 cells (46.7%) have an expected count of less than 5. The minimum expected count is .18.

Table 32. Relationship between the Number of Traffic Tickets Received in 2019 and the Vehicle Type

Vehicle Type	Number of Traffic Tickets Received in 2019					Total
	None	1-2	3-4	5-6	More than 6	
Private	67.4%	59.0%	26.3%	40.0%	66.7%	56.3%
Public	17.4%	25.6%	68.4%	60.0%	33.3%	31.3%
Public bus	2.2%	2.6%	5.3%			2.7%
Cargo truck	4.3%	2.6%				2.7%
Operating engineers	2.2%					0.9%
Bulldozer	2.2%	2.6%				1.8%
Commercial and light truck	4.3%	7.7%				4.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 33. Correlation between the Number of Traffic Tickets and the Type of Vehicle)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	23.475a	24	.492
Likelihood Ratio	24.936	24	.409
Linear-by-Linear Association	.163	1	.686
No of Cases	112		

a. 29 cells (82.9%) have an expected count of less than 5. The minimum expected count is .03.

Table 34. Relationship between the Number of Traffic Accidents in 2019 and the Vehicle Type

Vehicle Type	Number of Traffic Accidents in 2019			Total
	None	1-2	3-4	
Private	56.8%	55.6%	50.0%	56.3%
Public	28.4%	38.9%		31.3%
Public bus	2.7%	2.8%		2.7%
Cargo truck	2.7%	2.8%		2.7%
Operating engineers	1.4%			0.9%
Bulldozer	2.7%			1.8%
Commercial and light truck	5.4%		50.0%	4.5%
Total	100.0%	100.0%	100.0%	100.0%

Table 35. Correlation between the Number of Traffic Accidents and the Type of Vehicle)

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	14.207a	12	.288
Likelihood Ratio	11.162	12	.515
Linear-by-Linear Association	.102	1	.749
N of Cases	112		

a. 17 cells (81.0%) have an expected count of less than 5. The minimum expected count is .02.

Table 36. Relationship between the Number of Traffic Tickets Issued in 2019 and the Years of Driving

Years of Driving	Number of Traffic Tickets You Received in 2019					Total
	None	1-2	3-4	5-6	More than 6	
Less than 5	39.1%	12.8%	5.3%	20.0%	33.3%	23.2%
5-9	17.4%	41.0%	26.3%	40.0%		27.7%
10-14	8.7%	20.5%	31.6%		33.3%	17.0%
15-19	13.0%	10.3%	10.5%	20.0%		11.6%
More than 20	21.7%	15.4%	26.3%	20.0%	33.3%	20.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 37. Correlation between the Number of Traffic Tickets and Years of Driving

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	22.770a	16	.120
Likelihood Ratio	25.120	16	.068
Linear-by-Linear Association	1.578	1	.209
No of Cases	112		

a. 15 cells (60.0%) have an expected count of less than 5. The minimum expected count is .35.

Table 38. Relationship between the Number of Accidents in 2019 and Years of Driving

Years of Driving	Number of Traffic Accidents in 2019			Total
	None	1-2	3-4	
Less than 5	25.7%	16.7%	50.0%	23.2%
5-9	24.3%	33.3%	50.0%	27.7%
10-14	14.9%	22.2%		17.0%
15-19	10.8%	13.9%		11.6%
More than 20	24.3%	13.9%		20.5%
Total	100.0%	100.0%	100.0%	100.0%

Table 39. Correlation between the Number of Accidents and Years of Driving)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.808a	8	.669
Likelihood Ratio	6.637	8	.576
Linear-by-Linear Association	.657	1	.418
No of Cases	112		

a. 6 cells (40.0%) have an expected count of less than 5. The minimum expected count is .23.

Table 40. Relationship between the Number of Traffic Tickets and the Number of Accidents in 2019

No of Traffic Tickets Received in 2019	Number of Traffic Accidents in 2019			Total
	None	1-2	3-4	
none	50.0%	22.2%	50.0%	41.1%
1-2	33.8%	36.1%	50.0%	34.8%
3-4	8.1%	36.1%		17.0%
5-6	5.4%	2.8%		4.5%
More than 6	2.7%	2.8%		2.7%
Total	100.0%	100.0%	100.0%	100.0%

Table 41. Correlation between the Number of Traffic Tickets and the Number of Accidents in 2019)

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	16.823a	8	.032
Likelihood Ratio	16.753	8	.033
Linear-by-Linear Association	3.952	1	.047
No of Cases	112		

a. 9 cells (60.0%) have an expected count of less than 5. The minimum expected count is .05.