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Awareness of pesticides' residues in food and feed among students of the Faculty of Agriculture, Mutah University, Jordan

Amani Al-Dawood [a], Samar Shawaqfeh [b,*], Firas Al-Zyoud [c], Amer Mamkagh [d], Raed Al-Atiyat [e], Hanan Hasan [b]

[a] Dept. of Applied Biology, College of Sciences, Tafila Technical University, Tafila, Jordan
[b] Dept. of Plant Production and Protection, Faculty of Agriculture, Jerash University, Jerash, Jordan
[c] Dept. of Plant Protection and Integrated Pest Management, Faculty of Agriculture, Mutah University, Karak, Jordan
[d] Dept. of Plant Production, Faculty of Agriculture, Mutah University, Karak, 61710, Jordan
[e] Dept. of Animal Production, Faculty of Agriculture, Mutah University, Karak, 61710 Jordan

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ABSTRACT

In Jordan, the public is still unaware of the fate and impact of pesticide application. This study aimed to evaluate the attitudes, knowledge and practices of undergraduate students enrolled in various academic departments at the Faculty of Agriculture, Mutah University, Jordan toward pesticides' residues in food and feed. Students were questioned about their social aspects, and food and feed safety knowledge and resources. Responses have been obtained from 209 responding students. Results indicated that the cross-section through the Faculty of Agriculture, Mutah University, Jordan appears a satisfactory. The findings show that respondents are very highly concerned about human health, food safety, and the risk of environmental pollution, and they have a real desire to reduce the use of pesticides. Respondents had a moderate level of knowledge about food safety, pesticides' side effects, pesticides' residues in food or feed, and usage of pesticides in homes and gardens. According to the respondents, the most common way that people are exposed to pesticide residues is by consuming pesticide residues in food. The respondents expressed a moderate level of concern about their attitudes toward organic farming adoption. Correlations between demographic variables and knowledge of food and feed safety, involving a workshop on food/feed safety, care about human health as well as environmental pollution, and looking for information on food/feed safety were reported in the study.

1. Introduction

In addition to crop damages (Elahi et al., 2021), the climate change is one of reasons to increase pest infestation, hundreds of pests on the earth affect the quality and quantity of agricultural crops (Al-Zyoud, 2014a & 2014b). Growing global food demand has resulted in a challenge for producing higher yields of crops and pressurized it to use non-renewable energy at farms which causes to increase carbon emissions, climate change, and pest infestation (Elahi et al., 2022). The major pest control approach followed by the farmers is the massive applications of synthetic pesticides (Al-Zyoud 2014c; Al-Zyoud et al., 2015, 2021). Pesticides are used to manage pests such as weeds, insects, nematodes, bacteria and fungi (Sanchez-Bayo et al., 2011). They are a quick effective and simple approach farmers rely on for reducing agricultural pests. (Owusu-Boateng and Amuzu, 2013).

Unfortunately, chemical pesticides not have the selective option of killing the target pest without harming the beneficial organisms. The intense use of pesticides negatively affect terrestrial ecosystems, a harmful side effect which in turn is reflected on human, animals and plants (Siddique et al., 2020). The massive usage of synthetic chemicals in modern agriculture come at a significant cost, and nowadays pesticides have been recorded widely (Al-Zyoud, 2014c). Many side effects have been recorded due to the human exposure to synthetic herbicides such as reproductive

* Corresponding author at: Department of Plant Production and Protection, Faculty of Agriculture, Jerash University, 26150 Jerash, Jordan.
E-mail addresses: dr_amani_aldaoud@ttu.edu.jo (A. Al-Dawood), s.shawaqfeh@jpu.edu.jo (S. Shawaqfeh), firaszud@mutah.edu.jo (F. Al-Zyoud), amer_mam@mutah.edu.jo (A. Mamkagh), ratiyat@mutah.edu.jo (R. Al-Atiyat).
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system, nervous system, immune system (Campagna et al., 2009), asthma, cancer, diabetes (Amanullah and Hari, 2011; Jayashree and Singhi, 2011), Alzheimer, Parkinson, allergies (Hong et al., 2014), and death (Raipulis et al., 2009). Whereas, in the environment it is represented in soil, air, rivers and groundwater (Maitah et al., 2015; Pattnaik et al., 2020). Using of high rates and frequent applications of pesticide applications have negatively affected aquatic ecosystem (Backhaus et al., 2019), predators and parasitoids (Al-Zyoud, 2014c), birds (Mitra et al., 2011), fish (Pattnaik et al. 2020), and plants (Andrade et al., 2015). In addition, absorption of pesticides by plants, accumulate in human and animal bodies through the food chain (Pattnaik et al., 2020). The persistence of some pesticides caused residues in animal organs, tissues, and blood, and this leads to human dietary exposure to such chemicals via animal products' consumption (Pattnaik et al., 2020). Animals exposed to pesticides through either contaminated water or feed. Residues of pesticides in goats, sheep, cattle and chicken has been recorded globally (Singha et al., 2014), in human blood (Pattnaik et al., 2020), soils (Maitah et al., 2015), and sheep milk (Choudhary et al., 2018). Projections showed that deaths and diseases due to pesticides' poisoning are one million/year globally (Pattnaik et al., 2020).

Growers' knowledge on pesticides uses and their negative effects on humans and environment is minimum. It is doubtful if growers follow the recommendations of the application rates of pesticides. In addition, their observance of the pre-harvest application time interval is questionable (Al-Zyoud, 2014c). At the global scale, it is well known that pesticides are not used in a correct manner (Maitah et al., 2015). Human exposure to pesticides via contaminated food or polluted water with pesticides; or living close to areas with intense applications of pesticides expos humans to pesticides (Damalas and Eleftherohorinos, 2011).

Food safety knowledge in any sector of the society is important because low knowledge and unwillingness to adopt food safety practices could precipitate foodborne illnesses that could increase the economic burden of the society. In this regard, looking for alternative pest management methods that reduce the environmental risks of pesticides is a critical need (Ghabeish et al., 2021, 2022). Equally, the secondary poisoning of consumers by eating contaminated food with pesticides is a present worry-affecting individual in various ways. Due to their extensive use worldwide, pesticides' residues have been raised in food and water (Damalas and Eleftherohorinos, 2011). Pests of agriculture and public health can be managed without the use of pesticides (Al-Zyoud et al., 2015, 2021). Using of integrated pest management (IPM) and organic farming was successful in decreasing the use of pesticides and for production of safe agricultural products nationwide (Al-Zyoud et al., 2021). Furthermore, some important practices should be followed before consuming fruits and vegetables, such as fruit skin peeling (Andrade et al., 2015), washing with water and getting rid of meat fats because they store a significant amount of pesticides' residues (Satpathy et al., 2012).

Public education program is an important step to increase the awareness level about pesticide residues (Maitah et al., 2015). Understanding students' food safety knowledge and practices will help developing effective means to decrease foodborne health risks (Udo et al., 2020). Low environmental awareness' level and negative attitude have been reported among various society members, such as students and teachers (Udo et al., 2020). Awareness of students about pesticide residues has significant gaps, not only in Jordan but also globally. The side effects of pesticide applications in Jordan remain largely unknown for the human eye. For this purpose, the objectives of this study.

aimed to evaluate the attitudes, knowledge and practices of undergraduate students enrolled in various academic departments at the Faculty of Agriculture, Mutah University, Jordan. Students were evaluated for their awareness of adverse effects of pesticides on food and feed.

2. Materials and methods

2.1. Questionnaire development

For the questionnaire, questions were developed and sent to various food and feed safety, and pesticide residues' specialists for additional suggestions. Once the responses were received from the specialists, their comments, notes, and suggestions were used in developing the final version of the questionnaire. The questionnaire was established to determine the awareness about health implications associated with pesticides' residues in food and feed among students at the Faculty of Agriculture, Mutah University, Jordan. The students were invited by email to answer the questionnaire online, questionnaire was also shared in many WhatsApp groups by students. The goal of the study was stated to the college students through a covering letter accompanied by the questionnaire to seek their consent. This step was made to ensure their participation, which was important for this study. Follow-up emails and phone calls to non-respondent students were made to encourage their participation and to explain any question in the surveying questionnaire. The survey study was done in 2022. All research ethics, i.e., participant' privacy and integrity, data confidentiality, and result anonymity were ensured during the research process.

2.2. Structure of the survey data

The factors affecting food and feed safety knowledge and practices are socioeconomic characteristics of the respondents. For addressing the awareness about health problems associated with pesticides' residues in food and feed among students, the questionnaire was consisted of four main sections. These sections were (1) demographics of the respondents (university students), (2) general food and feed safety, (3) pesticide residues, food and feed safety knowledge, and (4) information resources on food and feed safety. The first five questions in the questionnaire stated the students' demographics, i.e., gender, age, academic department, academic year level, and economic status of the respondents. The second section (question six to eleven) addressed the general pesticide residues, and food and feed safety knowledge including care about human health and food safety, environmental pollution, and wishing to decrease pesticides, as well as if students had faced pesticide-related symptoms after eating any type of food, and if they heard that abuse of pesticides in agriculture causes many health problems. Questions (twelve to forty-two) covered in the third section entitled pesticide residues and food and feed safety knowledge. This section addressed students' level of knowledge of food safety, pesticide residues in food or feed, and side effects of pesticides, use of pesticides in home, garden, or field, ways people exposed to pesticides, ways that would help in reducing pesticide residues in food, and knowledge of waiting period. The third section covered also the complete dependency on pesticide use, farmers use pesticides with less knowledge about their negative effects on humans, pesticides absorbed by plants, pesticides introduced into livestock/animals mainly through feed or contaminated water, the role of organic farming, attitudes towards organic farming adoption, discussion about food safety, reasons that cause high pesticide residues in food, living near pesticide-treated areas, animals feed on contaminated feed and water, development of spraying machines and equipment to reduce negative effects of pesticides. Section four (questions forty-three to forty-five) addressed students' involvement in a workshop on food/feed

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safety, looking for information on food/feed safety, and if students would like to have information about food or feed safety.

2.3. Response outcomes and statistical analysis

Two hundred and nine (n = 209) completed questionnaires were sent to us via email, who made the initial evaluation of the obtained questionnaires for completeness. The obtained data were compiled in a spreadsheet, and then data were coded. A series of yes/no answers; no, limited, medium and good knowledge answers; not used, rarely, sometimes, and always answers; strongly disagree, disagree, neither agree nor disagree, agree and strongly agree answers; never, seldom, sometimes, often, and very often answers; and very unlikely, unlikely, undecided, likely, and very likely answers were included in the questionnaire. For data coding, the responding students stated answers of implementations that is, not implementing (no) = 1, or implementing a practice (yes) = 2. Student females were given 1, while student males were given 2. A codification key was established and the numbers 1, 2, 3 and 4 were given to the possible answers: no knowledge, limited knowledge, medium knowledge, and good knowledge, respectively; as well as not used (1), rarely (2), sometimes (3), and always (4) answers. Furthermore, another codification manual was established and numbers from 1 to 5 were assigned to the possible responses; strongly disagree, disagree, neither agree nor disagree, agree and strongly agree answers, respectively; never, seldom, sometimes, often, and very often answers, respectively; and very unlikely, unlikely, undecided, likely, and very likely answers, respectively. For each item the final value was calculated by multiplying the assigned value by the responses' number. Due to that multiple choices could be selected by each responding student in some questions, percentages do not sum to 100. Descriptive and inferential statistics such as means and their compartments standard errors, percentages and frequencies were used to analyze the data. Such an analysis provides statistics that are used to describe the data' basic features in the current study. For correlation of academic year level, the 1st, 2nd, 3rd, and 4th years were given values of 1 to 4, respectively. For the income (JD), <400, 401–600, 601–1000, 1001–1500, 1501–2000, and > 2000 was assigned values of 1, 2, 3, 4, 5, and 6, respectively. Spearman's correlation analysis procedure was performed to examine pair-wise associations among demographics of the students (gender, age, academic year level, and income) and each knowledge of food and feed safety, involving in a workshop on food/feed safety, care about human health and environmental pollution, and looking for information of food/feed safety (Zar 1999). Proc GLM of the statistical package SigmaStat version 17.0 were used for data statistical analysis (SPSS 1997).

3. Results

3.1. Demographics of respondents

There were 209 respondents in this survey study. The data showed a satisfactory cross-section throughout the Faculty of Agriculture, Mutah University. The student females represented 53.11% of the respondents, while student males' percentage was only 46.89% (Table 1). Most of the students (23.45% and 22.49%) were 19 and 20 years old, respectively, while only ~ 12% of the students were 22 years old (Table 1). The highest percentage of responding students was obtained from the Departments of Animal Production (27.75%) and Nutrition and Food Industry (27.75%), followed by the Department of Plant Protection and IPM (23.45%), while, the lowest percentage of responses was recorded from the Department of Plant Production with only 21.05% (Table 1). According to the academic year level, the 2nd year-student recorded the highest percentage of respondents with one-third, followed by the 3rd year (one-fourth), then the 1st and 4th year with about one-fifth (Table 1). About one-third of the respondents had a monthly income of < 400 JD (~34%) and 401–600 JD (~30%), and about a quarter of them had 601–1000 JD (~25%), while very low percentage (~12%) of them had more than 1000 JD/month (Table 1).

Table 1
Demographics of respondents according to gender, age, academic department and year, and income (n = 209).

	Item	Frequency of students	Percentage of students (%)
Gender	Female	111	53.11
	Male	98	46.89
Age (year)	19	49	23.45
	20	47	22.49
	21	30	14.35
	22	25	11.96
	23	30	14.35
	>23	28	13.40
Academic department	Animal Production	58	27.75
	Nutrition and Food Industry	58	27.75
	Plant Production	44	21.05
	Plant Protection and IPM	49	23.45
Academic year level	1st year	44	21.05
	2nd year	69	33.02
	3rd year	51	24.40
	4th year	45	21.53
Monthly income (JD)	<400	71	33.96
	401–600	62	29.67
	601–1000	51	24.40
	1001–1500	16	07.66
	1501–2000	02	00.96
	>2000	07	03.35

3.2. General human health, food safety and environment

The respondents very highly cared about human health, food safety (95.69%), risk of environmental pollution (92.82%), and wished to decrease pesticides' use (90.43%). Meanwhile about three-fourths of them thought that government policies could lead to increase food safety (Table 2). The most faced injuries and illnesses due to pesticides mentioned by the respondents are allergy (38.28%) and headache or dizziness (37.32%), followed by skin irritation, stomach cramps, and breathing difficulty accounting for about one-fifth of the respondents for each (Table 2). It is well known for more than half of the respondents that massive pesticide use could contaminate water, air and soil. Additionally, pesticides cause cancer (37.80%), kill birds and wildlife (36.84%), cause immune suppression (33.02), death (32.54%) and asthma (31.58%). However, only 6.7% of the students know that pesticides can cause diabetes (Table 2).

3.3. Pesticides' residues, food and feed safety knowledge

Respondents reported that they have a moderate level of concern about four selected tasks of pesticides' residues, and food and feed safety. The levels of concerns were in the following decreasing order: level of knowledge about food safety (2.80 out of 4), level of knowledge of pesticides' side effects (2.73 out of 4), level of knowledge about pesticide residues in food or feed (2.56 out of 4), and usage of pesticides in respondents' homes, gardens or fields (2.47 out of 4) (Table 3).

Results indicated that almost half of the respondents know that pesticides caused allergic effects. Upon the respondents, the most way that people are exposed to pesticide residues is through ingesting pesticide residues in food (54%), while a very low

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Table 2
General issues related to human health, food safety and environment, illnesses and injuries caused by pesticides stated by students and knowledge of negative effects of massive use of pesticides in agriculture (n = 209).

	Item	Frequency of students	Percentage of students (%)
*General issues related to human health, food safety and environment	Care about human health and food safety	200	95.69
	Care about environment pollution (water, soil and air)	194	92.82
	Wish to decrease pesticides' use	189	90.43
	Think that government policies will lead to increase food and feed safety	156	74.64
*Pesticide-related illnesses and injuries faced by respondents	Headache or dizziness	78	37.32
	Disturbance in vision	25	11.96
	Excessive salivation and sweating	18	08.61
	Stomach cramps	43	20.57
	Unable to walk and weakness	16	07.66
	Chest discomfort	32	15.31
	Muscle twitches	07	03.35
	Secretions from nose and mouth	14	06.70
	Breathing difficulty	41	19.62
	Allergy	80	38.28
	Skin irritation	45	21.53
	None	51	24.40
*Heard that extensive use of pesticides in agriculture causes:	Death	68	32.54
	Immune suppression	69	33.02
	Hormone disruption	45	21.53
	Reproductive abnormalities and decreased fertility	41	19.62
	Nervous system disorders	44	21.05
	Cancer	79	37.80
	Asthma	66	31.58
	Diabetes	14	06.70
	Contaminate water, soil and air	109	52.15
	Kill birds and wildlife	77	36.84

* Because multiple choices could be selected by each student, percentages do not sum to 100.

percentage was given to contaminated surfaces (5.26%), and the use of pesticides in the garden (6.7%) (Table 4). To reduce pesticides' residues in food, about one-third and two-thirds of respondents indicated that pesticide-reduction policies from the government and pesticides' users should be trained to avoid adverse effects on humans, respectively (Table 4). To decrease residues of pesticides in fruits and vegetables, 39.71% of the respondents mentioned washing the contaminated fruits and vegetables with water, followed by washing with dilute solutions of salt (33.01%), meanwhile, very low percentages were given to washing with detergent solutions (11%) and peeling or cooking contaminated fruits and vegetables (10%) (Table 4).

According to the respondents, the harmful response of human health to pesticides came in the first rank (43.54%), followed by environment (water, soil and air) (19.14%). Almost 68% of the respondents believed that animals feed on contaminated feed and water could have pesticides' residues in meat, milk or eggs. People are most exposed to direct or subsequent effects of pesticides through sprayer operators (40.19%), followed by residents' people live near sprayed areas (21.05%), while a very low percentage (~4%) believed that bystanders could be exposed to pesticides. The best approaches to decrease the negative impacts of pesticides were to produce more products that are organic (35.41%) use advanced technology in spraying operations (25.84%), improve the pesticides' industry (22.49%), and development of spraying machines (16.27%) (Table 4).

A high percentage (~83–87%) of respondents reported that they know the following issues: pesticides' residues are taken by crops, and entered the food chain, and hereafter accumulated in the bodies of humans and animal. However, chemicals used in animal husbandry can cause public health concerns. Farmers use pesticides extensively without knowing their negative impacts on humans and environment. Chemicals are introduced into animals through contaminated feed or polluted water, and controlled insects on animals. Furthermore, respondents believed that the testing of pesticides residues in the food is a good approach for reducing the harmful effect. (~86%), and the development of spraying machines and equipment will reduce the negative effects of pesticides (~80.4%) (Table 5). More than four-fifths of the respondents heard about organic farming. Only 71% of respondents heard about the waiting period (is the waiting time between a pesticide application and when a crop can be safely harvested), and ~ 77% thought that there are appropriate safety measures that are taken by machine workers when using pesticides in the field. While 78% believed that the development of spraying equipment and machines and using advanced technology in spraying operations negatively affect food and feed prices (Table 5).

The respondents reported that they have a moderate level of concern about their attitudes toward organic farming adoption (3.57 out of 5), producing organic products on their farms will provide healthy food and feed (3.48 out of 5), plan to grow organic products in their farms within the near future (3.40 out of 5). In contrast, only about half (2.53 out of 5) of the respondents discussed food safety issues (Table 6).

Some important issues related to human health, environment, pesticides' residues and food as well as feed safety knowledge reported by respondents according to the academic department are shown in Table 7. The Departments of Animal Production and Plant Production received the highest scores in 10 and 4 of the 14 items, respectively. In contrast, each of the Department of Nutrition and Food Industry and the Department of Plant Protection and IPM scored the highest in only 1 item out of 14 (Table 7). In total out

Table 3
Respondents' knowledge of some selected tasks of pesticides' residues, and food and feed safety (n = 209).

Task	No knowledge	Limited knowledge	Medium knowledge	Good knowledge	Final point value (mean of 4)
Level of knowledge about food and feed safety	12	33	149	15	2.80
Level of knowledge about pesticides' residues in food or feed	19	61	122	07	2.56
Level of knowledge of pesticides' side effects	14	44	135	16	2.73
	Not used	Rarely	Sometimes	Always	Final point value (mean of 4)
Usage of pesticides in homes, gardens or fields	32	55	114	08	2.47

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Table 4
General tasks related to pesticide residues in food and feed reported by respondents (n = 209).

	Item	Frequency of students	Percentage of students (%)
The most common pesticides' side effects	Acute effects	37	17.70
	Chronic effects	65	31.10
	Allergic effects	107	51.20
*The most ways that people exposed to pesticides' residues	Through ingesting pesticides' residues in food	113	54.07
	Through drinking contaminated water	44	21.05
	Through inhaling air contaminated by pesticides	52	24.88
	Once use pesticides in the house to control pests	82	39.23
	Once use pesticides in the garden to control pests	14	06.70
	Once use pesticides in residential areas as fogging	35	16.75
	Once use pesticides in farmland close to houses	44	21.05
	Contaminated surfaces	11	05.26
The points that help more in reducing pesticides' residues in food	Pesticides' spray drift from treated fields causes unacceptable effects to bystanders and residents	23	11.01
	Pesticide-reduction policies from the government	70	33.49
	Users of pesticides should be trained to avoid adverse effects on humans	139	66.51
Steps you find to decrease pesticides' residues in crops	Washing the contaminated vegetables and fruits with water	83	39.71
	Washing the contaminated fruits and vegetables with dilute solutions of salt	69	33.01
	Washing the contaminated fruits and vegetables with detergent solutions	23	11.01
	Peeling or cooking the contaminated fruits and vegetables	21	10.05
	None of the above	13	06.22
Pesticides are more harmful to	Human	91	43.54
	Animals	15	07.18
	Plant diversity	23	11.01
	Environment (water, soil and air)	40	19.14
Reasons cause the more presence of pesticides' residues in food	Direct application of pesticides on crops	105	50.24
	Animal feeding on pesticide-treated feed	54	25.84
	Contaminated environment (water, soil and air)	50	23.92
Are you living near?	Sprayed areas	30	14.35
	Pesticides' storage facilities	15	07.18
	Greenhouses	20	09.57
	Open fields	33	15.79
	None of the above	111	53.11
Animals that feed on contaminated feed and water could have pesticides' residues in	Meat	19	09.09
	Milk	33	15.79
	Eggs	14	06.70
	All of them	143	68.42
People who are the most exposed to direct or subsequent effects of pesticides	Sprayer operators	84	40.19
	Farm tractor operators	17	08.13
	Harvesting workers	21	10.05
	Agricultural workers	35	16.75
	Bystanders	08	03.83
	Resident people near sprayed areas	44	21.05
The best way to reduce the negative effects of pesticides	Produce more organic products	74	35.41
	Development of spraying machines	34	16.27
	Using advanced technology in spraying operations	54	25.84
	Improve the pesticides' industry	47	22.49

* Because multiple choices could be selected by each student, percentages do not sum to 100.

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Table 5
General issues related to pesticides' residues and food and feed safety knowledge mentioned by responding students (n = 209).

Item	Frequency of students	Percentage of students (%)
Hear about the waiting period	163	77.99
Know that controlling insects on animals, carpets and furniture expose people to pesticides	174	83.25
Know that intense pesticide use in agriculture caused their diffusion to the environment	182	87.08
Know that growers use pesticides without a full understanding of their effects on human and environment	177	84.69
Know that pesticides' residues are absorbed by crops, enter the food chain and accumulate in human and animals	183	87.56
Know that pesticides are introduced into animals through contaminated feed or water	174	83.25
Know that chemicals used in animal husbandry can cause public health concerns	183	87.56
Heard about organic farming	175	83.73
Think that there are appropriate safety measures that taken for machine workers when using pesticides in the field	160	76.56
Think that development of spraying machines and equipment will reduce the negative effects of pesticides	168	80.38
Believe that development of spraying equipment and machines and using advanced technology in spraying operations negatively affect food and feed prices	149	71.29
Believe that testing the feed for pesticides' residues is considered as a good agricultural management	180	86.12

of 40 scores, the Departments of Animal Production, Plant Production, Plant Protection and IPM and Nutrition and Food Industry scored 31.35, 30.41, 29.88 and 29.81, respectively (Table 7).

3.4. Information resources on food and feed safety

Only 43% of the respondents have been involved in food/feed safety workshops. Almost 60% of the respondents reported seeking for food/feed safety information. Almost 47.4% of the responding students would like to obtain food/feed safety information through the Ministry of Agriculture (MOA), followed by continuing education (~39%), and online information (~36%). In contrast, commercial media (22%) was the least preferred by students (Table 8).

3.5. Correlation analysis

Correlation analyses between demographic variables of the responding students, particular food and feed safety' practices, tasks, or issues are demonstrated in Table 9. The findings showed that gender was correlated significantly and positively with involvement in workshops on food/feed safety, and side effects of pesticides ($r = 0.190$, $P = 0.006$), negatively and significantly increased with knowledge of food/feed safety ($r = -0.152$, $P = 0.028$). This means that in spite of males being more involved in workshops, females had more knowledge of food/feed safety. Also, age ($r = 0.169$, $P = 0.014$) and academic year level ($r = 0.186$, $P = 0.007$) were positively and significantly correlated with involvement in workshops on food/feed safety, and side effects of pesticides, while only academic year level was positively and significantly correlated with knowledge of food/feed safety, and side effects of pesticides ($r = 0.145$, $P = 0.036$). Furthermore, income was correlated positively and significantly with involvement in workshops on food/feed safety ($r = 0.133$, $P = 0.027$).

4. Discussion

Pesticides played a major role in providing quantities and qualities agricultural products to consumers, and ensuring good profits for farmers. In spite of that synthetic pesticides are developed to work with low risk to humans and their environment, concerns have been raised about their residues in food, feed and water (Alananbeh and Hayajneh 2019). Understanding university students' food safety, knowledge and practices will help develop effective measures to improve human health and decrease environmental risk (Udo et al. 2020).

4.1. Demographics of respondents

The data indicated a good representation across the gender, age, academic department and year level and income. The female students' percentage was higher than male students, which is in full agreement with Alananbeh and Hayajneh, (2019) who conducted a survey at the Jordan University. The majority of the responding students were 19 and 20 year old. Furthermore, we obtained ~ 21–28% for each of the four surveyed academic departments, and students from all four academic year levels were surveyed. The percentage of respondents decreased with increasing monthly income. In this regard, Udo et al. (2020) showed that gender, education level (of respondents and household heads), and household head income were statistically significant in explaining the likelihood of students' willingness to adopt food safety practices. In addition, the results show that the age, education level,

Table 6
Respondents related issues towards organic farming (n = 209).

Task	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Final point value (mean of 5)
Attitudes toward organic farming adoption	10	13	76	68	42	3.57
Producing organic products in your farm will provide healthy food and feed	11	15	79	70	34	3.48
	Never	Seldom	Sometimes	Often	Very often	Final point value (mean of 5)
Discussion about food safety	40	59	82	16	12	2.53
	Very unlikely	Unlikely	Undecided	Likely	Very likely	Final point value (mean of 5)
Plan to grow organic products in your farm within the near future	14	25	60	84	26	3.40

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Table 7
Some important issues related to human health, environment, pesticides' residues and food and feed safety knowledge according to the academic department as reported by respondents (n = 209).

Department/item	Score out of	Animal Production	Nutrition and Food Industry	Plant Production	Plant Protection and IPM
Care about human health and food safety	2	1.97	1.98	1.93	1.94
Care about environment pollution	2	1.93	1.90	1.93	1.92
Wish to decrease pesticides' use	2	1.97	1.86	1.91	1.88
Level of knowledge about food and feed safety	4	2.79	2.81	2.86	2.73
Level of knowledge about pesticides' residues in food or feed	4	2.72	2.50	2.57	2.41
Level of knowledge of pesticides' side effects	4	2.72	2.66	2.80	2.78
Hear about the waiting period	2	1.88	1.74	1.80	1.70
Know that extensive use of pesticides in agriculture caused their diffusion to the environment	2	1.93	1.83	1.91	1.86
Know that growers use pesticides without understanding of their negative effects on human health and environment	2	1.90	1.79	1.89	1.82
Know that pesticides' residues are absorbed by crops, enter the food chain and accumulate in human and animals	2	1.93	1.83	1.86	1.88
Attitudes toward organic farming adoption	5	3.66	3.38	3.84	3.45
Discussion about food safety	5	2.78	2.52	2.36	2.39
Involving in food/feed safety workshop	2	1.50	1.41	1.30	1.50
Seeking for food/feed safety information	2	1.67	1.60	1.45	1.63
Total score	40	31.35	29.81	30.41	29.88

Table 8
Food and feed safety resources and needed information indicated by respondents (n = 209).

	Item	Frequency of students	Percentages of students (%)
Involving in food/feed safety workshop		90	43.06
Seeking for food/feed safety information		125	59.81
*How you would like to have information about food or feed safety?	Ministry of Agriculture (MOA)	99	47.37
	Continuing education	81	38.76
	Online information	75	35.89
	Commercial media (television, radio, newspaper	46	22.01

* Because multiple choices could be selected by each student, percentages do not sum to 100.

Table 9
Correlations' analysis between demographic variables of the responding students and particular food and feed safety' practices, tasks or issues (n = 209).

Correlated variables	r	Significance
Care about human health and environmental pollution vs. gender	−0.084	0.226
Care about human health and environmental pollution vs. age	0.076	0.227
Care about human health and environmental pollution vs. year level	0.021	0.765
Care about human health and environmental pollution vs. income	0.039	0.290
Knowledge of food/feed safety, and side effects of pesticides vs. gender	−0.152*	0.028
Knowledge of food/feed safety, and side effects of pesticides vs. age	0.116	0.094
Knowledge of food/feed safety, and side effects of pesticides vs. year level	0.145*	0.036
Knowledge of food/feed safety, and side effects of pesticides vs. income	0.110	0.113
Involving in workshops on food/feed safety, and side effects of pesticides vs. gender	0.190**	0.006
Involving in workshops on food/feed safety vs. age	0.169*	0.014
Involving in workshops on food/feed safety vs. year level	0.186**	0.007
Involving in workshops on food/feed safety vs. income	0.133*	0.027
Looking for information on food/feed safety vs. Gender	0.105	0.129
Looking for information on food/feed safety vs. Age	0.115	0.096
Looking for information on food/feed safety vs. year level	0.086	0.215
Looking for information on food/feed safety vs. income	−0.050	0.474

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

and income level of the head of household of the respondents are significant in explaining the likelihood of a student having a high proficiency level.

4.2. General human health, food safety and environment

In the current study, the students very highly (>90%) cared about health of humans, risk of environment pollution, and wished to decrease pesticides' use. Thus, the findings clearly indicate a very high knowledge of students on the negative effects of pesticide usage on human health and environmental risks, thus, they will disseminate their knowledge after graduation to the community, which agrees with the results of Maitah et al., (2015). In the present study, the most faced illnesses and injuries related to pesticides mentioned by the students are allergy and headache or dizziness, followed by skin irritation, stomach cramps, and breathing difficulty. Our data agree with the findings of Al-Zyoud, (2014c), in which the responding growers stated similar pesticide-related illnesses and injuries. The present study indicated that more than half of the students know that massive pesticide use in agriculture can contaminate air, soil and water, cause cancer, immune suppression, diabetes, asthma and death, and kill birds and wildlife. Furthermore, a high percentage of respondents reported that they know the following issues: pesticides' residues are absorbed by crops, entered the food chain and then accumulated in humans and animal bodies, chemicals used in animal husbandry can cause public health concerns, and control insects on animals, carpets and furniture expose people to insecticides. This agreed with the outcomes of Alengebawy et al., (2021) and Al-Zyoud, (2014c) on other surveyed members of the community. Serious concerns about human health risks have raised from consumer exposure to pesticides (Damalas and Eleftherohorinos, 2011; Alananbeh and Hayajneh, 2019).

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4.3. Pesticide residues, and food and feed safety knowledge

Students in the present study reported that they have a moderate level of knowledge about food safety, pesticides' side effects, pesticide residues in food or feed, and usage of pesticides in homes, gardens or fields. In addition, government policies could lead to increase food safety, meanwhile, 2/3 of respondents indicated that users of pesticides should be trained to avoid adverse effects on humans. The role of college students in knowledge dissemination about safety of food is conclusive in the Jordanian community because the students are the future leaders in different governmental institutions (Hayajneh, 2016). Despite the regulations of pesticide use in many countries, pesticide residues are still reported in food and feed. In spite of that pesticides have developed to work with minimal risk to humans and the environment, the published findings are not in agreement with this fact (Damalas and Eleftherohorinos, 2011). Udo et al., (2020) reported that a high knowledge level of the students carried out food safety practices most times, This is possibly explained by the fact that the population is educated. Interestingly, Abushelaibi et al., (2016) report 87% appreciation of the importance of food safety by students from selected schools in the UAE. The mean concern about environment regarding air pollution and drinking water quality was ranked as a high concern (Arshad et al., (2021). Altin et al., (2014) measured the awareness of secondary schools' students in Turkey and stated that students have a high level of concern about environmental awareness. The situation of food and feed safety knowledge of the university students in the current study is very much encouraging.

Upon the respondents in the present study, the most way that people are exposed to pesticide residues is via ingesting pesticide residues in food, while a very low percentage was given to contaminated surfaces and pesticides usage in the gardens. According to the respondents, pesticides are more harmful to human health, followed by water, air and soil. The reasons for that related to the highest presence of pesticides' residues in food, half of the respondents mentioned the direct use of pesticides on food crops. About half of the respondents lived near pesticides' contaminated areas like open fields (15.79%), sprayed areas (14.35%), greenhouses (9.57%), and pesticides' storage facilities (7.18%). In this regard, Kim et al., (2016) and Damalas and Eleftherohorinos, (2011) reported that population exposure to synthetic pesticides happens mainly through food consumption and drinking water polluted by pesticides, while significant exposure to pesticides can occur when living close to an intense pesticide sprayed areas, storage facilities of pesticides, fields and/or greenhouses, also pesticide residues are found in wildlife species.

Among the main steps to decrease residues of the pesticides in fruits and vegetables, the respondents stated washing the contaminated fruits and vegetables with water, followed by dilute solutions of salt, detergent solutions and peeling or cooking. Andrade et al., (2015) reported that washing or peeling tomatoes reduce pesticide residues in the crop. In Spain, the residue levels of fipronil on beans were reduced by 50% (Aguilera et al., 2014). Srinivasa et al., (2018) show the decontamination effect of various pesticides on broad beans, the highest removal of all insecticides from green field pods was achieved with treatment formula 1 (4% acetic acid + 0.1% NaHCO3 + 1 lemon).

Respondents believed that animals feed on contaminated feed and water could have pesticide residues in meat, milk and eggs. This indicated that students are aware of the possible risks that could occur when feed, food or water with accumulated pesticide residues are consumed. The first pesticide exposure route for animals is by direct application of the pesticides on them, or through drinking of contaminated water (Sanchez-Bayo et al., 2011). The persistent nature of synthetic pesticides caused their accumulation in animal bodies. Studies indicated that tissue organs, and blood samples of goats were contaminated with pesticides (Singha et al., 2014; Choudhary et al., 2018). The occurrence of pesticide residues in milk and meat is of significant concern to ensure human health and food safety (Choudhary et al., 2018).

In the present study, students had a moderate level of concern about their attitudes towards organic farming adoption, producing organic products on their farms to provide healthy food and feed, plan to produce organic products on their farms within the near future. Furthermore, respondents believed that testing feed for pesticide residues considers good agricultural management, and the development of spraying machines and equipment will reduce the negative effects of pesticides. According to Alananbeh and Hayajneh, (2019), students had heard about organic food. El-Wakeel et al. (2023) reported that organic agriculture is a production system that relies on prevention, ecological processes, biodiversity, mechanical processes and natural cycles to control pests and maintain productivity. In organic agricultural ecosystems, pesticide use is often limited or not used at all, posing minimal risk to human health and the environment. Therefore, eating organic foods, especially fruits and vegetables, can largely eliminate the risk of dietary pesticide exposure (Benbrook et al., 2021).

Some more attention should be paid to the important issues related to human health, the environment, pesticides' residues and food and feed safety knowledge, especially at the Department of Plant Protection and IPM and the Department of Nutrition and Food Industry since they had the lowest scored compared to the Department of Animal Production which had the highest score, followed by the Department of Plant Production which came in the second position. In a similar fashion, Arshad et al., (2021) reported a high environment attitude, concern and awareness of college students across five academic disciplines, where the awareness was in the following decreasing order: biological sciences, environmental sciences, arts and humanities, physical sciences and social sciences.

4.4. Information resources on food and feed safety

Our study demonstrated that less than 50% of the students have involved in food/feed safety workshops. Almost 60% of the respondents reported seeking for food/feed safety information. Almost less than half of the students would like to have information about food/feed safety through MOA, followed by continuing education and online information. According to Alananbeh and Hayajneh, (2019), 67% of the students would like to learn more about pesticide residues. Thus, it is suggested to design and implement educational programs for students to make a huge contribution to prevent pesticide misuse (Owusu-Boateng and Amuzu, 2013). Different media, i.e., television, newspapers, and internet are the main communication routes through which community receive information and can be used to teach and educate Jordanian consumers (Hayajneh, 2016), and farmers (Al-Zyoud, 2014c; Maitah et al., 2015). The enrolled people in college courses (i.e., food safety) had higher knowledge, practice and attitude scores. The current findings should encourage college professors to increase their students' awareness, educational programs should be directed to the college students IPM training provide environmental consequences of the use of pesticides (Atreya, 2007).

4.5. Correlations

The current study indicated that in spite of males being more involved in workshops, females had more knowledge of food/feed safety. In addition, age, academic year level and income were positively and significantly correlated with involving in workshops on food/feed safety, and side effects of pesticides, while only academic year level had a positive and significant correlation with knowl-

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edge of food/feed safety, and side effects of pesticides. The current findings were in full agreement with previous studies regarding the educational role in awareness of food safety, pesticides and antibiotic residues in animals. In this regard, education level is positively correlated with awareness of food-borne pathogens (Hayajneh, 2016), and contributes to increasing knowledge and awareness of health risks associated with the consumption of foodstuffs with pesticide residues (Krishna and Qaim, 2008) which in full agreement of the current study. In addition, Owusu-Boateng and Amuzu, (2013) stated that good knowledge linked positively with the level of educational attainment. Also, the influence of the income of students in universities on their willingness to adopt food safety practices is negligible (Udo et al., 2020). Age, educational level and income are statistically significant in explaining the high knowledge of students in food safety in Akwa Ibom State University (Udo et al., 2020). Furthermore, Akabanda et al., (2017) found that education is positively significant in explaining the food safety knowledge of handlers in Ghana. Similarly, Moreb et al., (2017) found that age and educational level were significant in explaining knowledge of food safety. Gender showed a weak correlation regarding pesticide effects on humans, animals, plant diversity and environment. It is concluded that education has a positive role on creating awareness about the health hazards associated with pesticide usage. Almost all respondents had a good awareness of the side impacts of pesticide use on human health and the environment (Unklesbay et al., 1998).

5. Limitations of the Study

This is a survey questionnaire study that is not free of limitation, the main limitations for this study were:

- The observational, opinion-based study can compromise the quality of the results, however, the relatively high response rate to the survey increases the validity and reliability of these results.
- The participation was voluntarily, and the groups were not equally distributed; majority were male students, middle aged, and mid-level in their study.
- Sharing our students experience with different universities and public entities in the country could help to improve public awareness for human health, food safety, and the risk of environmental pollution, and hopefully enhance their desire to reduce the use of pesticides.

6. Conclusions

In conclusion, based on the current results it could be concluded that college students have high levels of food and feed safety, human health and environmental concerns. Results presented here display an awareness of students toward the use of pesticides and possess a good knowledge on the safe use of pesticides, therefore, estimating potential human health and environmental risks. Education and training programs should be launched for the students, community awareness creation and enforcement of laws regarding the pesticides' use for improving awareness of pesticides are important. The introduction of IPM and organic farming systems to the students will contribute in reducing the pesticide side effects on humans and the environment without affecting agriculture production. A wide range of media, i.e., television, radio, newspapers, posters, and formal training should disseminate the pesticide-relevant information end users. Awareness programs about pesticides' hazards will encourage users to treat pesticides with care, and minimize their use. We think more classes about food safety should be available for students in all departments. The study should be expanded to include a higher number of students from various Jordanian universities and from different colleges' backgrounds to be able to generalize the findings.

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All the authors contributed equally in searching for the literature, and in writing the first draft of the paper. FA read further and improved the final draft of the paper. SS edit and finalized the final draft of the paper.

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