

Comparative study of conventional and organic vegetable produce quality and public perception in Kuwait

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Abstract

Kuwait, like other Gulf Cooperation Council (GCC) countries, depends almost entirely on food imports for national food security with all the risks involved. There is a growing realization for the exigent necessity to enhance domestic production, and local farmers are adopting farming system they perceive as organic. Organic agriculture can be a proven solution for feeding people in a healthy and environmentally sustainable manner. This study was designed to investigate nutritive values and the safety of organic produce compared to conventionally grown vegetable crops sold in Kuwaiti supermarkets. Findings indicated slightly higher total nitrogen (TN) in organic than in conventionally grown crops, except lettuce (5.14% vs. 4.56% for broccoli, 4.5% vs. 1.34% for cabbage and 1.9% vs. 2.5% for lettuce). Total phosphorus (TP) levels, however, were lower in organic as compared to conventionally grown vegetable crops (3676.075 mg kg⁻¹ vs. 4545.2 mg kg⁻¹ for broccoli, 2416.3 mg kg⁻¹ vs. 2947 mg kg⁻¹ for cabbage and 4178.94 mg kg⁻¹ vs. 4555.31 mg kg⁻¹ for lettuce). With respect to heavy metals, the potential for arsenic (As), copper (Cu), lead (Pb) and zinc (Zn) transfer into vegetables was studied. Arsenic content was significantly ($p < 0.05$) greater in local organic lettuce (3.5 mg kg⁻¹) than other farming systems. Cu was highest (10.38 mg kg⁻¹) in local organic broccoli, and Zn content was highest in local organic lettuce (108.7 mg kg⁻¹). An accompanying public perception survey in Kuwait indicated a willingness of most consumers to spend more premium on organic produce because of the perception of it being healthier than conventional produce. People showed a preference to consume more organic food if it were grown locally with a reasonable price. While local farmers perceive their production system as completely organic, internationally recognized certification standards and regulations are currently non-existent. Therefore, an existing domestic farming system can only be described as organic by traditional practices.

Keywords: Farming systems; organic food; heavy metals; food market; sustainability.

1. Introduction

Global population currently stands close to 8.0 billion and is projected to reach approximately 10 billion by 2050 (UN, 2015). Populations are largely concentrated in urban centers. Consequently, the demand for food production will have to increase correspondingly, especially in developing countries where most of the population growth is occurring. This poses a particularly serious challenge for hot and arid regions with only marginally productive land and scarce water resources. This includes Kuwait and other countries with similar climatic and environmental conditions. There is a need for a new agricultural revolution where production increase and economic wealth go hand-in-hand with environmental and social sustainability. Although the Green Revolution

in 1950s was successful in feeding a rapidly growing human population and averting global food shortages and subsequent massive famine, there have been detrimental effects to the environment, and, consequently on public health due to a heavy reliance on synthetic agro-chemicals such as fertilizers and pesticides (Pimentel *et al.*, 2005).

Organic farming is gaining a growing interest among consumers and producers. The interest has augmented the international trade for organic products (Yussefi, 2017). Elevated demands of organic food production are primarily associated with changing dietary preferences because of an increasing standard of living worldwide. Shifting dietary consumption to organic food is mainly driven by belief in a healthy diet and the environmental benefits (Kesse-Guyot *et al.*, 2013). Reducing chemical

inputs improves soil's organic matter in organic agricultural systems. Therefore, there is less soil erosion. This is combined with other greater environmental benefits compared to conventional agriculture practices (Pimentel *et al.*, 2005).

In observational studies, consumers who regularly buy organic vegetables and fruits and consume less meat are reported to have overall healthier dietary patterns (Soltoft *et al.*, 2011; Kesse-Guyot *et al.*, 2013). Fresh vegetables, such as lettuce, broccoli, and cabbage, are the main agricultural produce in Kuwait (FAO, 2015). Recently, some farmers in Kuwait have started practicing what they perceive to be organic farming. However, since there are still no certified organic farms in Kuwait, these farming practice can best be described as organic by tradition. Farmers perceive their farming methods as organic based on the main premise that synthetic pesticides and fertilizers have not been applied to their fields.

To the best of our knowledge, no previous study has been done on assessing organic food quality sold in the supermarkets in Kuwait. Thus, the primary objective of this study was to investigate local and imported organic and conventional crops in terms of total phosphorous (TP), total nitrogen (TN), and selected heavy metals (Arsenic, Copper, Lead and Zinc). These are considered food safety indicators. The study was complemented with a public survey which investigated the perception about growing and consuming organic foods as opposed to conventionally grown foods sold in Kuwaiti supermarkets.

2. Materials and methods

Three vegetable crops were selected in this study for comparison: broccoli, cabbage and lettuce. These crops were chosen because they are commonly grown in Kuwait's greenhouse farms year-round and play an essential role in nutritious diets. Samples were collected from different parts of each plant, weighed and stored in empty glass containers for freeze-drying. Knowing there are no specifically certified organic farms in Kuwait, samples were still collected from volunteer farmers in the north from Abdaly Farms and in the southern east from Al-Wafra Farms (Figure 1). With respect to imported organic and conventional crops, samples were randomly collected from local co-operative grocery stores where they were labeled as such.

The tissues of crops were washed thoroughly with distilled water before being freeze-dried. Samples were chopped with the use of a titanium knife and teflon

chopping board, and then stored in glass containers. Due to the high moisture levels in the samples, the freeze-drying process was carried out until a constant weight was reached. Then the samples were loaded into a milling bowl with approximately 15 agate-milling balls (20-mm) and pulverized. Samples were analyzed immediately after extraction. However, in a few instances when immediate analysis was not possible, samples were refrigerated.

Samples were digested and subsequently analyzed for TP, on a dry-weight basis using the spectrophotometry standard method SRPS ISO (13730/1999). For total nitrogen (TN), samples were analyzed using LECO CHN/CHNS/OCHNS TruSpec Micro Analyzer (LECO Corporation, Saint Joseph, MI, USA). Preparation and analysis were performed according to ASTM D-4239 for sulfur, and D-5373 for carbon, hydrogen, and nitrogen. For metals, samples were digested for metal analysis using a Block Digester (Environmental Express, 2008) and analyzed with Inductively Coupled Plasma–Optical Emission Optima 7300 Spectrometer (PerkinElmer, USA). Samples of 0.5 g were weighed and placed in a polypropylene digestion vessel along with deionized water (DW) and nitric acid (HNO₃). They were then left for a cold digestion overnight. Analytical instruments were calibrated with a solution of known concentration. To minimize analytical error, all lab analyses were carried out in triplicates.

To understand public attitude toward organic foods in Kuwait, a public survey was conducted as part of this research. The goal was to estimate the preference for organic foods over conventional foods. The survey evaluated organic farming perceptions and the reasons that consumers chose to consume organic foods. The survey was randomly distributed between male and female participants of different age groups. A total of 415 respondents completed all the questions. Participants were first asked to define what constitutes organic produce.

All lab analyses were carried out in triplicates to minimize experimental errors. The data were subjected to an analysis of variance (ANOVA) to study the variation in the means of the parameters of interest using SPSS (version 25). Significant differences among means were determined by Tukey's pairwise comparison. Farming systems' effect on trace metals were analyzed and discussed separately, ignoring potential interactions for the sake of simplicity, since these crops were not grown in the same soil and environmental conditions. Statistically significance levels were determined at $p \leq 0.05$.



Fig. 1. Satellite image of Kuwait showing the location of agriculture

3. Results and discussion

3.1. TN and TP content

Total nitrogen (TN) and total phosphorus (TP) in broccoli, cabbage, and lettuce under different farming systems are shown in Figures 2 and 3, respectively. TN content

soil might have contained more carbon and nitrogen and a greater microbial biomass (Reganold *et al.*, 2010). Nitrogen content is an indicator of protein which implies higher food quality. In another study, the concentrations of proteins, amino acids and N were found to be lower in organic crops (Baranski *et al.*, 2014). A plausible reason for this inconsistency is that some organic farms used harvested fish water for irrigation that can be rich in nutrients including TN, while other farmers use other sources of organic fertilizers. Looking forward, it should be mentioned that which cropping system (conventional vs. organic) accumulates greater N has been a topic of inconsistent findings as some studies report significantly higher nitrogen contents in conventionally produced crops (Dangour *et al.*, 2009).

TP concentrations were significantly ($p < 0.05$) higher in local conventionally-grown cabbage and broccoli than in organic ones (Figure 3). The average contents of TP in conventional and organic crops were 4.605 g kg^{-1} and 3.842 g kg^{-1} , respectively. Local organic lettuce contained the greatest amount of TP compared to all other crops, regardless of the cropping system. This observation is consistent with research by Dangour *et al.* (2009). These authors reviewed a large number of studies that

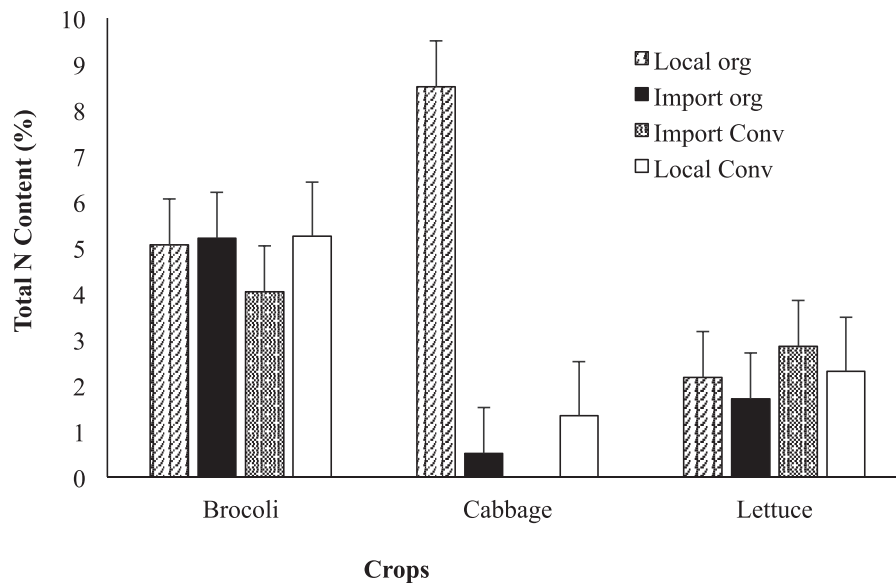


Fig. 2. Concentrations of Total nitrogen (TN) in Broccoli, Cabbage and Lettuce under various farming systems

varied with the crop type and farming system in which these crops have been grown (Figure 2). Broccoli and lettuce's N content did not differ significantly ($p > 0.05$) under any of the farming system, whereas locally grown organic cabbage showed a significantly higher N content (Figure 2). This could be because local organically farmed

comparing organic vs. conventional crops. They reported that organic crops contained 13.6% more phosphorus than conventional produce. The main message from this study is that there is no consistent trend for organically-grown crops being more nutritious than conventionally-grown produce.

3.2. Trace metal concentrations

Arsenic (As), Copper (Cu), Lead (Pb) and Zinc (Zn) concentrations are shown in Table 1. Cadmium (Cd) was analytically not detectable in any of the three crops under all farming systems. Consequently, Cd was excluded in the analysis and discussion. Similarly, Pb was not detected in broccoli and cabbage, and only trace amounts of Pb were measured in lettuce (Table 1). Relatively greater concentrations of As were measured in all local organic produce than in conventional produce (Table 1). The average content of As in the organic crops was 2.78 mg kg⁻¹ compared with the conventional crops of 1.01 mg kg⁻¹. A number of field studies have reported that As has a known affinity for uptake and translocation from roots to shoots of leafy crops (Raab *et al.*, 2007; Stilwell *et al.*, 2008). With respect to crop affinity in absorbing As, McBride *et al.* (2015) measured as uptake factors in the following order: lettuce > carrot > beans > tomato. To put our results in the context of existing health protective policies, however, as concentrations did not exceed international food safety standards (FAO, 2014).

were found to be lower than concentrations in cabbages, carrots, cauliflower, cucumbers, eggplants, green peppers, spinach, sweet potatoes and tomatoes (Chao *et al.*, 2007). Clark *et al.* (2008) reported that organic lettuce contained the highest concentrations of As and Pb and contained similar concentrations, although organic lettuce and broccoli were collected from the same farm. This indicates different metal absorption responses depending on vegetable type.

The concentrations of Cu are shown in Table 1. Copper is an essential element required for plant growth. However, higher concentrations (> 20.0~30.0 mg kg⁻¹) can be toxic (Lairon, 2009; Worthington, 2001). In our study, organic broccoli was found to contain 10.10 mg kg⁻¹ of Cu, almost 10 times the amount found in conventional broccoli. Cabbage contained similar concentrations of Cu in both organic and conventional samples. The average content of Cu was found to be slightly higher in the organic crops (5.49 mg kg⁻¹) than in the conventional crops (2.90 mg kg⁻¹). All tested samples were below the toxicity level of

Table 1. Selected trace metals concentrations (mg kg⁻¹) in locally grown organic (LO), imported organic (IO) and imported conventional (IC) crops.

Farming Systems	Trace metals											
	As			Cu			Pb			Zn		
	B [§]	C ^{§§}	L ^{§§§}	B	C	L	B	C	L	B	C	L
LO [¥]	2.11a [†] (0.57) ^{††}	3.43 (0.35)	3.5 a (0.32)	10.38a (1.54)	0.52a (0.04)	6.2a (0.44)	ND	ND	2.2a (0.17)	78.81a (1.72)	41.4a (0.42)	108.7a (5.21)
IO [€]	ND ^ϕ	ND	1.59b (0.22)	2.01b (0.15)	8.53b (1.0)	10.37b (1.02)	ND	ND	0.61b (0.06)	73.48a (0.40)	74.35b (0.35)	67.12b (0.52)
IC [£]	2.5a (0.32)	ND	ND	3.29b (1.34)	ND	6.27a (0.81)	ND	ND	ND	72.34b (0.55)	60.2c (1.18)	64.32b (1.54)
LC [¥]	1.3a (0.4)	ND	ND	1.02b (0.53)	1.3a (0.28)	4.08a (1.05)	ND	ND	1.04a (0.20)	57.43c (2.64)	55.79d (0.25)	71.25b (1.23)

[§]B = Broccoli, ^{§§}C = Cabbage, ^{§§§}L = Lettuce

[¥]LO = Local organic, [€]IO = Imported organic, [£]IC = Imported conventional, [¥]LC = Local conventional ^ϕND = Not Detectable

[†] Values within same column followed by different letters indicate statistically significant difference (Scheffe multiple comparison $P < 0.05$)

^{††} Values between parentheses are std. deviations

Pb was detected in both organic and conventional lettuce crops. However, on average, it was higher in organic crops (0.82 mg kg⁻¹) than in conventional crops (0.44 mg kg⁻¹). Exposure to Pb is a major concern because of its possible detrimental effects on human health. The European Union has set 0.3 mg kg⁻¹ wet weight for Pb as a maximum level when consuming leaf vegetables (EUCM, 2006). Absorption of heavy metals differs from crop to crop, regardless of the agricultural practices. For example, Pb concentrations in parsley and pumpkins

the Cu concentration. As shown in Table 1, local organic lettuce seems to accumulate Zn concentrations slightly higher than values reported in the literature (Jolly *et al.*, 2013; EU, 2000). In the other two crops under all farming systems, Zn concentrations remain within the global range (7-80 mg/kg) values (Jolly *et al.*, 2013).

Organic agriculture production in Kuwait is not certified. One important point to communicate here is that indigenous farming practices are widely assumed or considered by farmers to be synonymous with organic.

This assumption needs to be verified by applying certification standards. Otherwise, people may be buying and paying a higher price for products that are only marginally different from conventional products.

they bought and consumed organic food on a daily basis. About 88% said organic food is prohibitively expensive. On the other hand, 78%, 61%, and 32% perceived organic food as a healthier, safer and environmentally friendly,

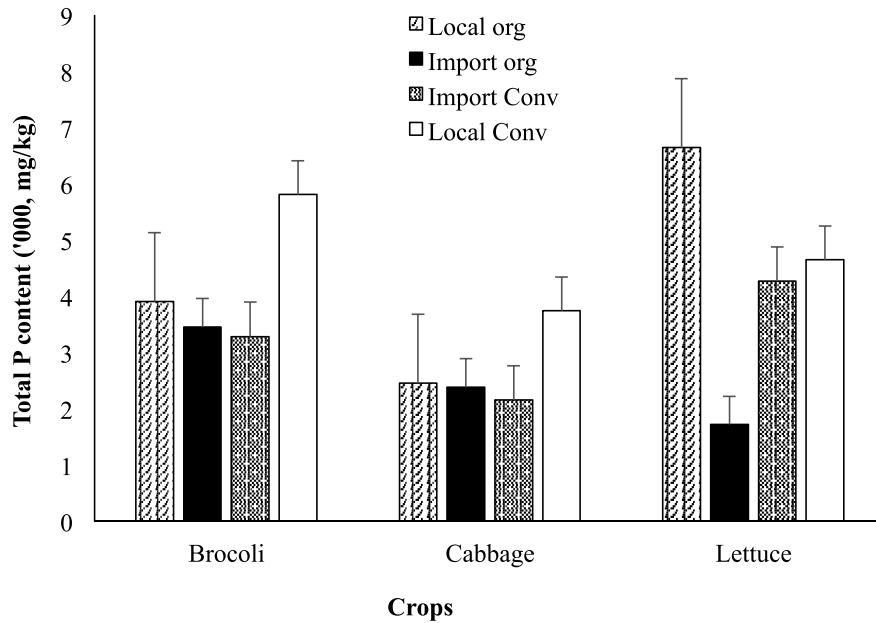


Fig. 3. Concentrations of Total nitrogen (TN) in Broccoli, Cabbage and Lettuce under various farming systems

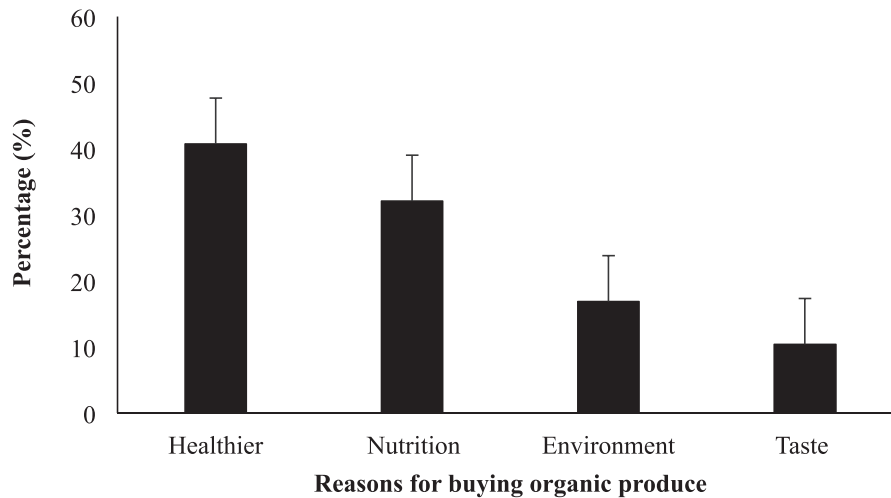


Fig. 4. Consumer reasons for buying organic food.

3.3. Public perception in Kuwait

More than half (58%) of the respondents were consistent with the broad definition of organic term, despite some misconceptions. Figure 4 shows participants’ desire to buy and consume organic produce and the frequency at which they buy it. The decreasing order for the reasons for buying organic produce provided by the survey participants is health > nutrition > environment > taste (Figure 4). Only a minor fraction of the respondents (3%) reported that

respectively. When people were asked their opinion, the majority (90%) of respondents said they would support a policy initiative for Kuwait agriculture to be converted into organic, which may promote lower prices for locally-produced organic products. Such an initiative would also provide for better food security.

4. Conclusion

This study investigated the status of local agriculture and evaluated the differences between products labelled or perceived as organic by tradition and conventionally grown commonly consumed vegetables. Results revealed higher concentrations of TN, As, Pb, Cu and Zn in organic crops than in conventional crops. Lower TP was seen in organic crops. Crop type is a critical determining factor along with soil properties in ascertaining the extent of trace metal bioaccumulation.

Consumers perceived organic food as healthy, safe and eco-friendly. A large number of consumers positively related to shifting to organic agriculture instead of conventional farming in Kuwait. As the region is looking toward sustainability, organic farming is a priority. It will help to achieve better food security. To encourage more organic farming in Kuwait, local farmers must be provided with the technical and financial support needed to transform into certified organic farming.

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دراسة مقارنة عن جودة إنتاج الخضروات التقليدية والعضوية والفهم العام لها في دولة الكويت

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الملخص

تعتمد دولة الكويت كغيرها من دول مجلس التعاون الخليجي بشكل كامل تقريباً على الواردات الغذائية للأمن الغذائي القومي وبالرغم من جميع المخاطر المرتبطة بها إلا أن هناك إدراك متزايد للضرورة الملحة لتعزيز الإنتاج المحلي، والمزارعون المحليون يتبنون نظام الزراعة الذي يرون أنه عضوي. صُممت هذه الدراسة للتحقق من القيم التغذوية وسلامة المنتجات العضوية مقارنة بمحاصيل الخضروات المزروعة تقليدياً والمباعة في محلات السوبر ماركت في الكويت. وأشارت النتائج إلى أن النيتروجين الكلي (TN) أعلى قليلاً في العضويات منه في المحاصيل المزروعة بشكل تقليدي، باستثناء الخس (5.14% مقابل 4.56% للبروكلي، 4.5% مقابل 1.34% للملفوف و 1.9% مقابل 2.5% للخس). ومع ذلك، كانت مستويات الفوسفور الكلية (TP) أقل في المركبات العضوية مقارنةً بمحاصيل الخضروات المزروعة تقليدياً (3676.075 ملغ/كجم⁻¹ مقابل 4545.2 ملغم/كجم⁻¹ للبروكلي و 2416.3 ملغ/كجم⁻¹ مقابل 2947 ملغ/كجم للملفوف و 4178.94 ملغ/كجم⁻¹ مقابل 4555.31 ملغم/كجم⁻¹ للخس). وفيما يتعلق بالمعادن الثقيلة، تمت دراسة إمكانية انتقال الزرنيخ (As) والنحاس (Cu) والرصاص (Pb) والزنك (Zn) إلى الخضروات. نظراً لأن المحتوى كان أكبر ($p < 0.05$) في الخس العضوي المحلي (3.5 ملغم / كجم⁻¹) مقارنةً بالنظم الزراعية الأخرى، كان النحاس (Cu) أعلى في البروكلي العضوي المحلي (10.38 ملغ / كجم⁻¹) وكان محتوى الزنك أعلى في الخس العضوي المحلي (108.7 ملغ / كجم). وأشارت الكويت إلى رغبة الجمهور في إنفاق المزيد من الأموال لاستهلاك المنتجات العضوية بالنظر إلى الصحة والسلامة، حيث أظهر الناس تفضيلاتهم لاستهلاك المزيد من الأغذية العضوية إذا ما نمت محلياً بسعر معقول. ويمكن أن تكون الزراعة العضوية حلاً مثبتاً لإطعام الناس بطريقة صحية ومستدامة بيئياً. وفي الوقت الذي يرى فيه المزارعون المحليون أن أعلافهم عضوية بالكامل، فإن المعايير واللوائح المعتمدة والمعترف بها دولياً غير موجودة. لذلك لا يمكن وصف النظام الزراعي المحلي القائم إلا بالممارسات التقليدية.