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A COMPREHENSIVE STUDY ON NUTRIENT CONTENT OF RAW AND ROASTED NUTS

Maryam H. AL-ZAHRANI[1], Lina A. BAZ[1], Faiqa B. SANDOKJI[1], Mawada M. BARNAWEE[1], Maha J. BALGOON[1], Faeza A. ALAZDI[1], Asmaa A. ALHARBI[1]

[1] Department of Biochemistry, Faculty of Science, King Abdulaziz University, Jeddah 21589, Saudi Arabia.

Corresponding author:
Maryam H. Al-Zahrani
mhsalzahrani@kau.edu.sa

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Abstract

Nuts are highly valued for their properties and are consumed worldwide owing to their health benefits, particularly, for the prevention and treatment of diseases, as well as a source of essential macro- and micronutrients. This study aimed to evaluate the effects of roasting on the nutritional value of nuts. Three types of nuts, raw and roasted almonds, cashews, and walnuts were selected from three well-known companies in Saudi Arabia. To analyze and evaluate the stability of macro- and micronutrients in nuts, modern separation and quantification methods, including inductively coupled plasma-optical emission spectrometry (ICP-OSE), were used to analyze and evaluate the stability of nutrients and heavy metals in nuts that are widely distributed and consumed. The results of this study indicate that nuts have high nutritional value and an inverse roasting effect. Comparing the nutrient and metal contents of raw and roasted nuts provides useful information on the nutritional science of nuts consumed by well-known manufacturers in the Kingdom of Saudi Arabia. Further investigations of nuts are needed to draw firm conclusions regarding their association with the prevention of many different diseases.

Keywords: Minerals. Nutrition value. Nuts. Raw. Roast.

1. Introduction

Nuts are highly valued for their properties and are consumed worldwide because of their taste and health benefits, including essential macro- and micronutrients, such as minerals, carbohydrates, phenol compounds, vitamins, and polyunsaturated fatty acids (Christopoulos and Tsantili 2015; Bailey and Stein 2020).

The risk of coronary heart disease, cholesterol, and inflammation was reduced by the consumption of nuts (Bernstein et al. 2014; Wojdyło et al. 2022). They are also associated with a decreased risk of cancer, diabetes, hyperlipidemia, and obesity (Olabiyi et al. 2018; Wojdyło et al. 2022). Studies have shown that it is a protective agent against hypertension and Alzheimer's disease (Zong et al. 2012; Gorji et al. 2018). Therefore, nuts are excellent nutrients and snacks for growing children and adults (Eslami et al. 2022). Therefore, individuals have increased their awareness of nuts as a healthy alternative. This has led to increased awareness among companies that produce nuts of various shapes and flavors that are preferred by consumers.

All nuts can be roasted, which gives them a distinctive flavor and aroma, as well as their texture (Srichamnong and Srzednicki 2015). During roasting, the Maillard reaction is responsible for many colors

and flavors, water content, and lipid modifications in food (Alamprese et al. 2009). This thermal process must be controlled to prevent lipid oxidation (Yaacoub et al. 2008).

In this study, modern separation and quantification methods, including inductively coupled plasma-optical emission spectrometry (ICP-OSE), were used to analyze and evaluate the stability of nutrients and heavy metals in nuts that are widely distributed and consumed.

To the best of our knowledge, no study has analyzed the chemical changes in raw nuts after roasting according to the Saudi culture. Few studies have examined the effect of roasting on the chemical nature of nuts in terms of their potential health benefits or consequences.

Therefore, this study aims to analyze the three most commonly consumed types of nuts in Saudi markets (almonds, cashews, and walnuts), from three well-known companies in Saudi Arabia to determine the effect of roasting on the nutritional components and mineral content of raw and roasted nuts. Comparing the nutrient and metal contents of raw and roasted nuts provides useful information on the nutritional science of nuts consumed by well-known manufacturers in the Kingdom of Saudi Arabia.

2. Material and Methods

Sample collection

Raw and commercially roasted nuts (almonds, cashews, and walnuts) (1 kg each) were purchased from three major local nut companies in Saudi Arabia and were divided into three groups (X, Y, and Z). Each group contained six types of nuts: I - raw almonds, II - raw cashews, III - raw walnuts, IV - roasted almonds, V - roasted cashews, and VI - roasted walnuts. The following samples were analyzed: American almond (*Prunus amygdalus*), Vietnamese cashew (*Anacardium occidentale*), and American walnut (*Juglans regia*).

Determination of moisture and Ash content

The moisture content was determined in accordance with the Association of Official Analytical Chemists AOAC Official Method 925.40 (Cunniff 1995). A 2g sample of each group was placed in an aluminum pan and dried in a previously heated vacuum oven (95–100°C) for two hours. The ash content was then measured using the AOAC Official Method 923.03 (Cunniff 1995). The samples were placed in a ceramic crucible, and then in a muffle furnace maintained at 550°C until the constant final weight of ash was reached.

Determination of crude fiber content

The crude fiber content was measured after consecutive treatments of the samples with light petroleum ether and diluted H_2SO_4 acid (0.1N) (Prasad and Bisht 2011). Subsequently, 2g of ground material was extracted with ether or petroleum ether to remove fat at boiling temperatures of 35°C to 52°C. The material was then filtered through muslin, washed with boiling water, and boiled with a sodium hydroxide solution for 30 min.

Determination of the crude lipid content

Crude lipid content was determined as described by Bligh and Dyer (Nielsen 2017). The samples (1g each) were weighed and ground in 5 mL of distilled water. They were then transferred to a conical flask with 15 mL of a chloroform and ethanol mixture (2:1 v/v), mixed well for 30 min at room temperature (25°C) in the dark, and centrifuged for 10–15 minutes at 2000–3000 rpm. The lower organic layer containing the entire lipid was carefully collected. The organic layer was placed in a pre-weighed beaker (W1) and carefully evaporated by placing the sample in a warm water bath. When the solution was free of organic solvents, its weight was measured (W2).

The weight of lipids = W1 – W2 = Z g lipids/1 g sample.

where Z is the difference between the weights, g is the grams.
To calculate the kilocalories provided by the sample:
1 g of lipid yield 9 kcal and Z g will yield of the sample = Z × 9 = Y kcal

Determination of the crude protein content

Crude protein content was determined using the dye-binding method. Bradford reagent was prepared by dissolving 100 mg Coomassie Brilliant Blue in 50 mL of 95% ethanol and adding 100 mL 85% (w/v) phosphoric acid. The solution was diluted with distilled water to a final concentration of 0.01%. The protein was extracted from the nut, which was placed in hot water at 70°C (100 g/600 mL) for 15 min, then filtered with a thin cloth of 0.318 mm pore size to separate the insoluble residue. This process was repeated seven times until a paste was obtained. The total protein content of the samples was measured against a standard solution of bovine serum albumin at 595 nm.

Determination of the carbohydrate content

The carbohydrate content was determined using a nitrogen-free extract (NFE) as per the AOAC Official Method 925.40 (Cunniff 1995), which was calculated using the following equation:
NFE% = 100 – (crude protein + crude fat + ash+ moisture + crude fiber)

Determination of ascorbic acid (vitamin C)

Vitamin C was detected by direct titration with iodine (Bailey 1974). The sample was ground with distilled water 1:10, w/v by a mortar and pestle, centrifuged at 4°C for 20 min at 4000 × g, and the supernatant was collected. For titration, 20 mL of the sample solution, 2 mL of oxalic acid, 150 mL of distilled water, and 1 mL of starch indicator solution were added to a 250 mL conical flask. The samples were titrated with a 0.005 mol/L iodine solution. The endpoint of the titration was identified as the first distinct trace of a dark blue-black color due to the formation of a starch-iodine complex. The titration was repeated thrice.
1 L 1N of iodine (I2) = M.Wt. of vitamin C (ascorbic acid) (179.14 g/mol)
1 mL (0.01N) of iodine (I2) = 176.14 g /1000*10*2 of ascorbic acid
1 mL (0.01N) of (I-)= 0.0088 g of ascorbic acid
Titer no. of iodine (I-) = T
Ascorbic acid = T *0.0088g /1 mL = Y gm
% Ascorbic acid = Y / sample weight *100 = Z g%

Determination of nicotinic acid (vitamin B3)

Vitamin B3 was detected via direct titration with iodine. Approximately 2 g of the sample was weighed, finely ground in a mortar with approximately 10 mL of distilled water, and centrifuged at 3000 rpm for 10 min. Subsequently, the supernatant was transferred to a conical flask for titration, using drops of phenolphthalein as an indicator. It was then titrated with 0.1 N NaOH until the endpoint was reached.
1L 1N of sodium hydroxide = Molecular weight of nicotinic acid
1 mL (0.1 N) NaOH = 123.11/100*10 gm of nicotinic acid
1mL (0.1 N) NaOH = 0.0123 gm of nicotinic acid
Nicotinic acid in the sample = titer number × 0.0123 / 1 mL = Y g
Gm % nicotinic acid = Y / sample weight × 100 = Z.

Determination of the heavy metals content

The heavy metal content was assessed using ICP-OSE (PerkinElmer Life and Analytical Sciences, Shelton, CT, USA), DG-FO-61, and a SpectrAA 880 Varian Atomic Absorption Spectrophotometer (Varian

Inc. USA). Acid digestion of the samples (0.5 g) was performed in a closed-vessel device using temperature-controlled microwave heating. The microwave digestion Tetrafluoromethane (TFM) vessel was introduced into the safety shield and 7 mL of 65% HNO_3, and 1 mL of 30% H_2O_2. Subsequently, the microwave program was completed. The rotor was cooled in air or water until the solution reached the room temperature. The solution in the vessel was then transferred to a marked flask and analyzed by ICP-OSE.

The heavy metal contents of the samples were quantified against standard solutions of known concentrations, which were analyzed concurrently follows: the Agilent Technologies for calcium (Ca), iron (Fe), magnesium (Mg), sodium (Na), silver (Ag), aluminum (Al), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), and zinc (Zn).

The selected emission lines, presented in nanometers, were Ag3280, Al3961, As1890, Ba4554, Be3130, Cd2288, Co2286, Cu3247, Fe2382, Mn2576, Ni2316, Pb2203, and Zn2062.

All tests were performed three times and subsequently averaged. Statistical analyses were performed using SPSS (Statistical Program for Social Sciences) version 17.0 for Windows. All analyses were conducted in triplicate, data were reported as means ± standard deviation (SD), and differences between means were considered significant at $p<0.05$.

3. Results

The moisture content was measured, as shown in Table 1. In all samples, a decrease of weight approximately 1–4% after drying. The color of the nuts did not change, but they became dry and slightly rigid owing to extreme heat. Company X experienced the largest decrease in moisture.

Table 1. The weight of samples to determine moisture and ash content in 100 g. Sample letters are (X, Y, Z) based on the type of companies.

The companies	Weight samples before drying (100 g)	Weight samples after drying for moisture	Weight samples after drying for Ash
X	Raw almonds	103 g	101 g
	Raw cashews	101.2 g	98 g
	Raw walnuts	99 g	96.5 g
	Roasted almonds	98.5g	97 g
	Roasted cashews	97.5g	96 g
	Roasted walnuts	101.5 g	100.5 g
Y	Raw almonds	100 g	99 g
	Raw cashews	102.5 g	99 g
	Raw walnuts	99.5 g	97.5 g
	Roasted almonds	101 g	100 g
	Roasted cashews	104.5 g	103.5 g
	Roasted walnuts	104 g	102 g
Z	Raw almonds	97.5 g	96 g
	Raw cashews	103 g	101 g
	Raw walnuts	101 g	99 g
	Roasted almonds	101.5 g	101 g
	Roasted cashews	100 g	99 g
	Roasted walnuts	98 g	97 g

The ash contents after weighing the samples are presented in Tables 2, 3, and 4. A reasonable and logical decrease in the weight was observed. The color of the nuts changed to silvery-black.

The crude fiber contents of the samples are listed in Tables 2, 3, and 4. In company X samples raw cashews had the lowest crude fiber, while the highest value was observed in roasted cashews. In company Y, two roasted nuts samples company Y, had the lowest crude fiber value, while the highest value was observed for raw walnuts. In company Z, the lowest crude fiber value was the roasted walnut, while the highest value was roasted almond.

The crude lipid content (as shown in Table 2, 3, and 4) were the highest company X roasted walnut samples, but raw walnuts had the lowest value. Raw almonds and cashews from company Y had equal crude lipid content and were among the lowest crude lipid values in this group. Roasted cashew samples

had the highest crude lipid value in company Y. In the company Z, roasted almonds had the lowest crude lipid value, while roasted cashews had the highest value.

Table 2. The nutrients content in X company.

X	Raw	Roasted	
	Carbohydrates (%)		Difference (%)
Almonds	144.16	152.61	-8.45
Cashews	137.10	125.10	12
Walnuts	105.59	191.12	-85.53
	Proteins (%)		
Almonds	0.16	0.11	0.05
Cashews	0.10	0.10	0
Walnuts	0.09	0.12	-0.03
	Lipids (%)		
Almonds	40	48	8
Cashews	55	26	29
Walnuts	22	84	-62
	Fiber (%)		
Almonds	16.50	15.50	1
Cashews	5	23.50	-18.5
Walnuts	5.50	11	-5.5
	Ascorbic acid (%)		
Almonds	0.62	0.62	0
Cashews	0.35	0.44	-0.17
Walnuts	0.92	0.99	-0.07
	Nicotinic acid (%)		
Almonds	0.28	0.12	0.16
Cashews	0.18	0.17	0.01
Walnuts	0.06	0.18	-0.12

Table 3. The nutrients content in Y company.

Y	Raw	Roasted	
	Carbohydrates (%)		Difference (%)
Almonds	137.64	153.08	-15.44
Cashews	132.61	160.12	-27.51
Walnuts	166.13	139.61	26.52
	Proteins (%)		
Almonds	0.14	0.08	0.06
Cashews	0.11	0.12	
Walnuts	0.28	0.11	0.17
	Lipids (%)		
Almonds	29	48	-19
Cashews	29	26	3
Walnuts	37	84	-47
	Fiber (%)		
Almonds	26.50	21.50	5
Cashews	18	31.00	-13
Walnuts	48.00	4	44
	Ascorbic acid (%)		
Almonds	0.35	0.53	-0.18
Cashews	0.44	0.35	0.09
Walnuts	0.66	0.66	0
	Nicotinic acid (%)		
Almonds	0.12	0.31	-0.19
Cashews	0.31	0.12	0.19
Walnuts	0.12	0.06	0.06

The crude protein content of the samples is shown in Tables 2, 3, and 4. In company X, the lowest crude protein value was the raw walnut, and the highest value was the raw almond. In contrast, roasted

almonds in company Y had the lowest crude protein value, whereas the highest value was for raw walnut. In company Z, the lowest crude protein value was for roasted walnut, and the highest value was for roasted almond.

Table 4. The nutrients content in Z company.

Z	Raw	Roasted	
	Carbohydrates (%)		Difference (%)
Almonds	142.13	191.64	-49.51
Cashews	160.08	159.09	0.99
Walnuts	156.09	174.56	-18.47
	Proteins (%)		
Almonds	0.13	0.14	-0.01
Cashews	0.08	0.09	-0.01
Walnuts	0.09	0.06	0.03
	Lipids (%)		
Almonds	45	7	38
Cashews	52	63	-11
Walnuts	54	51	3
	Fiber (%)		
Almonds	22.00	33.50	-11.5
Cashews	16.50	8.00	8.5
Walnuts	18.50	4	14.5
	Ascorbic acid (%)		
Almonds	0.66	0.31	0.35
Cashews	0.53	0.44	0.09
Walnuts	1.85	0.97	0.88
	Nicotinic acid (%)		
Almonds	0.25	0.62	-0.37
Cashews	0.15	0.37	-0.22
Walnuts	0.06	0.15	-0.09

The carbohydrate content samples shown in Tables 2, 3, and 4 demonstrate that in X, roasted walnuts had the highest carbohydrate value, and roasted cashews had the lowest value. In Y, raw walnut had the highest carbohydrate value, and raw cashews had the lowest value. In Z, roasted almond had the highest carbohydrate, and raw almond had the lowest value.

The content of ascorbic acid in the samples, as shown in Tables 2, 3, and 4, showed that in X, raw cashews had the lowest value, and roasted walnut had the highest value. In Y, raw almonds and roasted cashews had equal ascorbic acid values and were among the lowest in this group. Raw and roasted walnuts had the highest ascorbic acid values in company Y. In Z, roasted almond had the lowest value, and raw walnut had the highest values.

The content of nicotinic acid (vitamin B3) in the samples shown in Table 2, 3 and 4 that the raw walnuts from company X had the lowest value, and raw almonds had the highest value. In company Y, roasted walnuts had the lowest nicotinic acid value, while raw walnut and roasted almond values were equal and among the highest values. In company Z, raw walnut had the lowest nicotinic acid, and roasted almond had the highest value.

The content of heavy metal in samples shown in Table 5 demonstrated that the lowest value was arsenic and not detected in (raw walnuts and roasted almonds, cashew and walnuts), while silver was not detected in (roasted cashews and walnuts), while zinc was the highest metal content in nuts.

4. Discussion

Nut compounds are associated with numerous health benefits and are affected by thermal processing. Therefore, the present study analyzed almonds, cashews, and walnuts to determine the effects of roasting on the nutritional components of essential macro- and micronutrient nuts from well-known manufacturers in the Kingdom of Saudi Arabia.

Of the three nut varieties analyzed, almonds exhibited the highest protein and nicotinic acid content, whereas walnuts were rich in lipids and ascorbic acid. They are high-protein foods with many health-promoting properties and contain vitamins and minerals essential for the normal functioning of the body. Almonds are a sustainable and nutritious food source that can be used in plant-based milk, snacks, and baked goods (Fulton et al. 2018). Whole nuts provide a generous amount of heart-healthy fat, plant protein, filling fibers (13% of the daily minimum), manganese, and small amounts of copper, iron, and zinc. Almonds had the highest dietary fiber content, followed by walnuts. Moreover, company X has the largest decrease in moisture, which means that it may be roasted for longer periods than that of the others.

Table 5. The heavy metal content (ppm) composition of the study samples. Results are the mean value/standard error of the mean for at least two independent experiments.

Sample	Nuts						Wavelength
	Raw almonds	Raw cashews	Raw walnuts	Roasted almonds	Roasted cashews	Roasted walnuts	
Ag-Silver	0.003037	0.00006058	0.00003762	0.00007646	ND	ND	3280
Al-Aluminum	0.5218	0.6755	0.9502	0.6028	0.6006	0.7769	3961
As-Arsenic	0.007736	0.00001013	ND	ND	ND	ND	1890
Ba-Barium	0.02312	0.01454	0.09308	0.1834	0.004855	0.2319	4554
Be-Beryllium	0.0001878	0.0002403	0.0002300	0.0002772	0.0002444	0.0002512	3130
Cd-Cadmium	0.001875	0.001379	0.002045	0.002665	0.001774	0.002137	2288
Co-Cobalt	0.001134	0.001548	0.0008245	0.002770	0.0006867	0.0008602	2286
Cu-copper	2.516	12.91	7.727	4.091	13.46	6.358	3247
Fe-iron	4.363	9.077	6.690	3.269	9.914	6.835	2382
Mn-Manganese	4.168	8.068	12.42	12.48	10.09	16.87	2576
Ni-Nickel	0.1251	0.1655	0.05563	0.1359	0.2055	0.06000	2316
Pb-Lead	0.02586	0.02485	0.01432	0.01877	0.01978	0.01081	2203
Zn-Zinc	18.30	20.99	18.67	29.48	27.40	17.54	2062

ND: not detected, ppm: parts per million.

Ash content, which is often regarded as an index of mineral content in biological mass, was quite low in both raw and roasted nuts. Although the raw and roasted nut values did not differ, the values in this study were lower than those in another study (Okonkwo and Ozoude 2014). Company X had the largest decrease in moisture, which means that it may have been less roasted than the others and did not lose its nutritional value.

The carbohydrate contents showed great variation in all company samples, with company Z having the highest for roasted almonds and raw and roasted cashews. For walnuts, company Y had the highest carbohydrate content before roasting at a rate of 166.13%, while company X had the lowest carbohydrate content after roasting at a rate of 139.61%. The reason for this difference may be the breakdown of sugars after exposure to heat, and some compounds, such as fatty acids, peptides, free amino acids, and vitamins, may be altered during the roasting process (Bagheri 2020).

The percentage of protein in almonds before roasting was similar in all companies, but the highest was in X and Y, and the lowest was in Z, at a rate of 0.13%. Company X had the closest average protein score for almonds, according to the U.S. Food and Drug Administration (Pape et al. 2004).

The percentage of protein in the cashews was not significantly affected by roasting. For walnuts, there was a great discrepancy in the results, as walnuts from the Y company had the highest rate of 0.28% before roasting. A large part of the protein was lost after roasting at a rate of 0.11%, and the lowest amount was obtained from Company Z, with a rate of 0.09% before roasting and 0.06% after roasting. These three nut varieties are rich in proteins (Hayes 2020). There is a large discrepancy in the results, as the results of the protein for walnuts in companies X and Y are similar to those of a previous study (Venkatachalam and Sathe 2006).

A significant change in the lipid content in almonds before and after roasting was observed in company Z, which had the highest variation between the results before and after roasting, with an average difference of 38%. Interestingly, the chemometric evaluation indicated that raw and roasted nuts were very similar to each other, although some originated from different countries. As for the walnuts, the

discrepancy was significant, as the percentage of fat in company X before roasting was 22% and after roasting was 84%, as well as in company Y before roasting was 37% and after roasting was 84%, which may be due to the addition of oil to companies X and Y samples. However, company Z showed the best results, as there was no high variation in the numbers before roasting 54% and after roasting 51%. The results for walnuts in companies X and Y (for carbohydrates, proteins, and fat) are not consistent with previous studies (Bagheri 2020; Dodevska et al. 2022). The results for fats in almonds, cashews, and walnuts of companies X and Z were not consistent with previous studies (Venkatachalam and Sathe 2006; Griffin and Dean 2017). This may be due to the exposure to high temperatures, which resulted in the loss of many components. There were no significant changes in the cashews and walnuts before and after roasting in lipids. This may be due to the temperature and lack of external roasting time (Bagheri 2020).

The tested nuts were also rich in vitamin C, with the highest amounts before roasting found in the X and Z raw walnuts. The high vitamin C content of walnuts also indicates that nuts, in both raw and processed forms, can be used to prevent or at least minimize the formation of carcinogenic substances from dietary materials (Okonkwo and Ozoude 2014). In Company Z, raw cashews accounted for 0.5%, which is consistent with other studies (Pradhan et al. 2021). Vitamin C is a water-soluble and temperature-sensitive vitamin; therefore, it is easily degraded during cooking, and elevated temperatures and long cooking times have been found to cause severe losses of vitamin C (Tian et al. 2016). In this study, Company Z received a grant for this fact.

Vitamin B3 has an important function and consists of flavin adenine dinucleotide (FAD) and Flavin mononucleotide (FMN) coenzymes (Okonkwo and Ozoude 2014). Nuts, such as almonds, cashew nuts, and walnuts, are good sources of B3 vitamins (Pradhan et al. 2021). These facts are inconsistent with those of another study showing that cashews are not a good sources of B3 vitamin (Griffin and Dean 2017). In this study, the percentage of vitamin B3 was the highest before roasting in the raw almonds of companies X and Z.

From the results for heavy metals, it shown that Al, Ba, Be, Cd, Co, Se, Cu, Fe, Mn, Ni, Pb, and Zn were successfully estimated, whereas in As and Ag was not. The highest Al and Pd contents were observed in raw walnuts, the highest Ba and Mn levels were observed in roasted walnuts, the highest Cu and Ni contents were observed in roasted cashew, the highest Fe content was observed in roasted and raw cashew, and the highest Zn content was observed in roasted almond.

In a previous study, the highest copper content was observed in walnuts (25.45 ± 21.51 ppm), calcium ranged from (1010–1600 ppm), zinc ranged from (45.2–62.8 ppm,) and iron ranged from (10.4–12.8-ppm), and Pb ranged from (2.6–4.1 ppm). The percentage of lead in cashew nuts (6.61 ± 0.68 ppm) in the current study is higher than the value reported in previous results (Suresh et al. 2011). The nuts have substantial amounts of vitamins, minerals, and nutrients. The presence of carbohydrates, fats, and proteins also make them good sources of energy. Even after roasting, the salting process provides great benefits for the long-term viability of foods and prevention of foodborne pathogenic microorganisms (Bagheri 2020).

5. Conclusions

In conclusion, the results of the experiments revealed the differences in nutritive substances in raw and roasted nuts that have important applications in nutrition sciences. The nuts have substantial amounts of nutrients, vitamins, and minerals. They are also a good source of energy because of the presence of carbohydrates, fats, and proteins. The nuts contain vitamins C and B6, which protect against carcinogenic substances and malfunction of metabolism from dietary materials. This indicates that nuts with high nutritional value still contain nutrients even after affecting them by roasting.

This study aimed to raise awareness about the nutritional and health benefits of consuming more nuts as part of a diversified, balanced, and healthy diet and lifestyle. It can also be useful for supplementation in schoolchildren's feeding programs, considering their allergic history.

Research limitations and complications Nuts are brought from local stores, which may experience different circumstances with respect to storage/processing factors, and the values of the active compounds could be affected.

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