



Physicochemical properties of Walnuts (*Juglans regia* L.) shells and kernels growing in different locations in Kurdistan region-Iraq

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Article info	Abstract
<p>Original: 17 July 2020 Revised: 10 August 2020 Accepted: 23 August 2020 Published online: 20 December 2020</p> <p>Key Words: walnut (<i>Juglans regia</i> L.); physicochemical properties, moisture content, refractive index</p>	<p>Some physicochemical properties of walnut shell, kernel and oil of fifteen samples of walnut grown in different locations in Kurdistan region-Iraq were determined. Three principal dimensions such as length, width and thickness, volume and projected area of walnut and its kernels were measured using image processing technique. Based on three principal dimensions, some dimensional properties including geometric mean diameter, arithmetic mean diameter, sphericity, volume and surface area of the nuts and kernels were calculated. Also gravimetric properties of nuts and kernels such as true density of nuts and kernels were studied. Furthermore other physical properties such as weight of nut, weight of kernel, percentage yield of walnut, total oil content, ash contents, moisture contents, pH value, relative density and refractive index of the oils were also determined.</p> <p>The variations in physical properties such as size dimensions, arithmetic mean diameter, geometric mean diameter, unit mass, sphericity, surface area, true density and volume of shells and kernel of walnuts as a function of the moisture content were determined. With an increase in the moisture content, the surface area, sphericity, true density and volume of shells and kernel of walnuts increased. In addition, the oil yields from the kernels had ranged between 36.07% to 70.24%. The moisture contents of shells and kernels ranged between 6.34% to 10.11% and 3.68% to 5.62%, respectively; and the ash content of kernels were ranged between 0.94% to 2.2%. On the other hand, the refractive index of oils were determined between 1.4734 and 1.4767, pH-values of kernel oils were ranged between 6.23 and 7.02 and the relative density were determined between 0.9746 and 0.9801. Finally the present study was showed that the walnut kernels in Kurdistan region did not show any considerable significant variations with reference to their physical and chemical properties.</p>

1. Introduction

Walnut is a fruit that belongs to the Juglandaceae family, *Juglans* variety *Juglans regia* L. [1]. This fruit is distributed widely all over the world. The production of walnut fruit exceeds nearly 1, 500, 000 metric tons in the world. With total production of around 25%, 20% and 11% Republic of china, United States of America and Islamic Republic of Iran are the main producers of walnut, respectively. The production of the walnut in the abovementioned countries has increased rapidly In the recent years [2]. The fruit of walnut contains four main parts: the kernel, the shell, and the green husk (Figure 1). It is widely cultivated due to its edible kernel. Walnut has a high calorie level and rich nutrient composition [3].

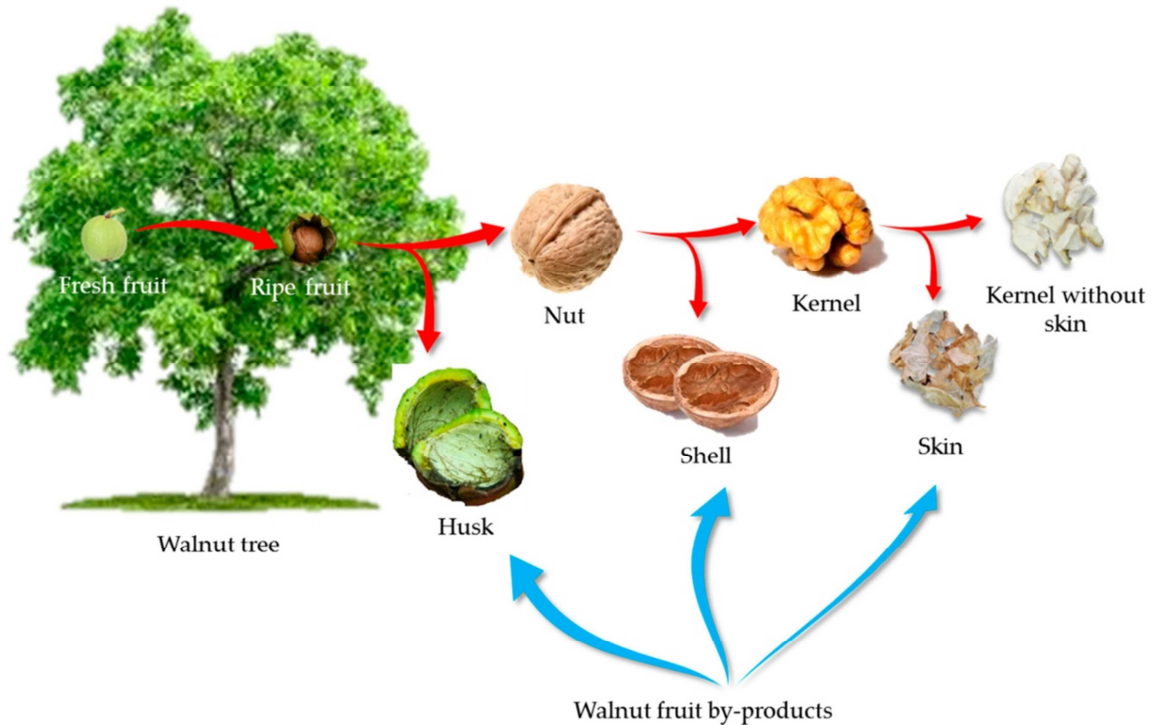


Figure 1: An unripe and young walnut fruit before its husk cracks and the ripe form of the fruit. Different parts of walnut fruit: kernel, skin, shell, and green husk. The shell and husk are the significant by-products of walnut fruit (Reprinted from [4]).

Walnuts have a high level of calorie and rich in nutrient composition as well. It can significantly contribute to daily diet if it is consumed in sufficient quantity. Because of its specific compounds such as polyunsaturated fatty acids in its compositions, it has functional importance in physiology and medical biochemistry. Walnut fruit is rich of oil and its oil can be consumed, alone or mixed with other edible products, freshly or toasted. The major components of walnut oil are triglycerides, in which monounsaturated (primarily oleic acid) and polyunsaturated fatty acids (linoleic and α -linolenic acids) are exists in high extents. The existence of other bioactive minor components, like phenols, phytosterols and tocopherols has been also documented in previous studies [5]. Walnut and walnut oil consumptions is due to the existence of high amount of natural antioxidants that has been reported previously as being protective against certain kinds of cancer and also decrease the risk of cardiovascular diseases [6].

Nut length, nut diameter, nut thickness, nut weight, kernel weight, kernel ratio, shell thickness, shell sphericity, true density, ash content, moisture content, pH value, oil composition, relative density and refractive index of some walnuts of Kurdistan region were investigated.

There is no published comprehensive literature on physical properties of shells and kernels of Kurdistan walnuts; therefore, the aim of the present work was to 1) determine the three principle dimension and surface area of walnut shells and kernels for fifteen samples of Kurdistan's walnut. 2) Measure some of the dimensional properties of walnut shells and kernels including arithmetic mean diameter, geometric mean diameter, volume, sphericity and surface area of the samples. 3) Determine the gravimetric properties of walnut shells and its kernels such as walnut mass, kernels mass, true density, moisture content, ash content, total oil content, pH value, relative density and refractive index of the oil.

The information on the physical properties of walnut shells and kernels like size dimensions, porosity, sphericity, volume, true densities and terminal velocity is important to design the equipment's that are used in harvesting, transporting, storing, handling, and processing of shells and kernel of the walnuts. The friction coefficient of shells and kernel walnuts on different surfaces are also essential to design the conveying, transporting, and storing the equipment. Porosity and bulk density play important role in the designing of

storage facilities of walnuts [7]. The size of walnut (such as length, thickness, breadth, arithmetic mean diameter and geometric mean diameter) and shape are important in the designing, harvesting, separating, sizing and grinding machines. The walnut shape is determined in terms of its sphericity and aspect ratio which affects the flow ability properties of the walnuts. Unit mass and true density are parameters that are used in the determination of the size of storage bins and also affect the structural loads. Surface area affects the resistance to airflow through bulk material bed and data on them are required in designing of the drying process. Fruit part fraction of walnut gives overall information about the components of kernel and its shell which affects the oil yield of the walnut product [8].

2. Materials and methods

2.1. Materials

2.1.1. Samples and storage conditions

Walnuts were collected from the walnut trees that growing in different locations in Kurdistan region-Iraq in September 2019 and a final sample of about three kilograms were taken randomly. After the harvest process, walnut fruits were dried in air conditions at ambient temperature. Samples were collected and stored in shelled paper then stored in the dark place in the laboratory at ambient temperature.

In this work some dimensional properties such as arithmetic mean diameter, geometric mean diameter, sphericity, surface area and volume of walnut shells and kernels, some physicochemical properties such as weight of nuts, weight of shells, weight of kernels, moisture content, true density, ash content, oil content, pH, relative density and refractive index of fifteen samples were analyses according to AOAC methods (Association of official analytical chemists) [9]. All samples were collected from different locations of Kurdistan region are: (1- Pallan Pe, 2- Sosakan, 3- Sikat (zakho), 4- Sharbazher, 5- Sharazur, 6- Penjwen, 7- Qaladze, 8- Xarpani, 9- Tawella, 10- Hawramani taxt, 11- Sartak, 12-Walzi, 13- Ballakayati, 14- Hawdian and 15- Akre). All samples were collected randomly on September 2019 to January 2020 and samples were collected and stored in shelled paper then stored in the dark place in the laboratory at ambient temperature.

2.1.2. Chemicals and reagents

Deionized water, distilled water, Nitric acid, Sulphuric acid, Hydrochloric acid, petroleum ether and anhydrous sodium sulphate. All of the chemicals were of analytical grade stored in the chemical laboratories.

2.1.3. Apparatus and Equipment

Crucible, analytical weighing balance (Scout Pro SPU 405, China), laboratory Oven (UMB 500 Schutzart, DIN EN 60529-IP 20, Memmert, Germany), Dial-micrometer to an accuracy of 0.01 mm, furnace (labtech), pH meter (WTwl- inolab-720), Refractometer (Rx-ATAGO), mortar, filter paper and hotplate.

2.2. Methods

2.2.1. Sample collection

The present study were performed on fifteen local samples from different locations in Kurdistan region that collected randomly on September 2019 to January 2020 and samples were collected and stored in shelled paper then stored in the dark place in the laboratory at ambient temperature.

2.2.2. Physical analyses

Physical properties of shells and kernel of walnuts were determined at three moisture levels. Each test was ten times replicated at each moisture level. The length, width, thickness, and the unit mass of walnut shells and kernels were measured for each moisture contents with randomly selected 20 walnuts. The length, width and thickness of the shells and kernels (Figure 2) were determined by a dial-micrometer with accuracy of 0.01 mm [7].

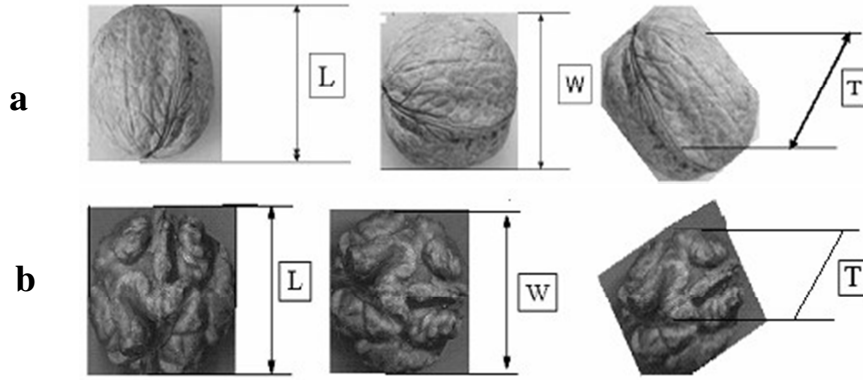


Figure 2: Description of three perpendicular dimensions of shells (a) and kernels (b) of walnuts. (Reprinted from [7]).

The Arithmetic mean diameter (A. M. D.), the geometric mean diameter (G. M. D.), the sphericity (ϕ), the Volume and the surface area of the shells and kernel of walnuts of all samples were measured using the relationships in table 1 [7].

Table 1: Parameters for determining the dimensional properties and the statistical indices of dimensions of walnut shells and kernels.

Sign	Parameter	Equation	Unit
A. M. D.	Arithmetic mean diameter	$\frac{L+W+T}{3}$	mm
G. M. D.	Geometric mean diameter	$(LWT)^{1/3}$	mm
L	Length of the nuts	---	mm
l	Length of the kernels	---	mm
S	Surface area of the walnuts	$\frac{\pi(G. M. D.)^2}{4}$	mm ²
T	Thickness of the nuts	---	mm
t	Thickness of the kernels	---	mm
V	Volume of the nuts and kernels	$\frac{\pi(G. M. D.)^3}{6}$	mm ³
W	Width of the nuts	---	mm
w	Width of the kernels	---	mm
ϕ	Sphericity	$\frac{(L * W * T)^{1/3}}{L} * 100$	%
ρ_t	True density	$\frac{m}{V}$	Kg.m ⁻³

The moisture contents of walnut kernel and shells were determined by using a laboratory oven (UMB 500 Schutzart, DIN EN 60529-IP 20, Memmert, Germany) at an isothermal temperature of 100°C for 24 hours [10]. The mass of the walnut shells and kernels were determined by using the electronic weighing balance (Scout Pro SPU 405, China) with an accuracy of 0.01 g. the difference of the moisture contents value and the mass of shells and kernels were reached by soaking the whole nut in water between 6 and 30 hours [7]. The soaked samples were removed from the water and stored in black polyethylene bottle in the refrigerator for two days. Each sample was removed from the refrigerator 24 hours before each experimental determination to reach moisture equilibrium within the sample and thawing. True density of all samples was measured by water immersion method [11] and water displacement method [12]. This was done by loosely filling a container of

known mass and volume with the walnut shells and kernel from a constant height. All of the other derived physical properties of walnut shells and kernels were measured quantitatively as presented in Table 2- 6. Microsoft Excel 2010 software was used to run the statistical analysis of samples.

2.2.2.1. Shelled and kernel weights of walnuts: It was used of 20 unit walnut samples randomly for each walnut variety. Each shell and kernel of walnuts was weighed separately and the average hulled fruit weights for each samples was determined (Table 3 and 5).

2.2.2.2. Shelled and kernel dimensions of walnuts: The dimensional properties of walnut shells and kernels such as length, width and thickness (Figure 2) were determined by a dial-micrometer with accuracy of 0.01 mm [7]. The result was taken in Table 2 and 4.

2.2.2.3. Percentage Yield of walnuts: Five walnut samples were used for measuring the yield analysis of each walnut. The percentage yield of walnut was measured by the percentage rate to the shelled walnut to the kernel weight (Table 5).

2.2.2.4. Determination of moisture content: twenty walnut samples were randomly used and weighed in an incubator calibrated to 100°C for 24 hours to remove all moisture in the shells and kernels [9].

2.3. Chemical Analysis

Some chemical compositions (such as Oil contents, Ash contents, pH value, relative density and refractive index of the oil) were measured according to AOAC methods [9]. For the oil analyses, each sample were homogenized and subjected to extraction for 6 hours with petroleum ether (boiling range 30-60°C) in a Soxhlet apparatus. The extracted oils were dried over anhydrous sodium sulphate and the solvent was removed under reduced pressure in a rotary film evaporator instrument. The oil percentage of each sample was determined by the weight difference [13]. The pH-Value of oil samples were performed at about 20°C using a pH-meter in grinded walnut samples diluted with freshly deionized water, the pH was measured using a digital PH-meter which was calibrated by using deionized water. Total ash contents were obtained by calcinations of 5g of each sample at 600 °C for 240 min [14]. The relative density of oil samples were determined by measuring the density of the each samples in a density bottle (glass pycnometer, pyrex, 25 ml) at 20°C [15]. The refractive index of all walnut samples were analysed according to AOAC methods were the extracted walnut oil of each samples are used to read its refractive index by using the refractometer instrument (Rx-ATAGO) [9].

3. RESULTS AND DISCUSSION

The physical and chemical properties of some walnut collected from some locations in Kurdistan region are given in Table 2-6. In this study some dimensional properties such as geometric mean diameter, arithmetic mean diameter, volume, sphericity and surface area of walnut shells and its kernels; some physicochemical properties such as weight of shells, weight of kernels, moisture content, true density, ash content, oil content, pH, relative density and refractive index of walnut oil were determined.

3.1. Dimensional properties

The walnut shells had length that ranging from 20.11 mm to 27.32 mm, the width of the shells had ranging from 18.23 mm to 25.56 mm and its thickness had ranging from 17.45 mm to 24.69 mm (Table 2); and its unit mass had ranging from 8.12 g to 14.53 g at 8.02 % moisture content (Table 3); and the walnut kernels had a length ranging from 17.03 mm to 21.86 mm, its width had ranging from 15.11 mm to 20.01 mm and thickness of walnut kernels had ranging from 14.88 mm to 19.53 mm (Table 4); and a unit mass of walnut kernels had ranging from 4.09 g to 8.01 g at 4.38 % moisture content (Table 5). The dimensional properties of walnut such as average length, thickness, width, the arithmetic mean diameter, the geometric mean diameter and the unit mass of the walnut shells had ranging between 20.11- 27.32 mm, 18.23-25.56 mm, 17.45-24.69 mm, 18.56-25.83 mm, 18.59-25.85 mm and 8.12-14.53 g, respectively, as the moisture content increased from 6.34 % to 10.11 %, the dimensional properties (length, width and thickness) of the walnut shells increased (Table 2 and 3), the same conditions are true for walnut kernels as the moisture content increased from 3.68 % to 5.62 %, respectively.

the dimensional properties (length, width and thickness) of the walnut kernels were also increased (Table 4 and 5). The effect of the moisture content on the walnut shells and kernels dimensions was not significant [7].

True density of the walnut shells and kernels at different levels of moisture contents had ranging from 613.75 kg/m³ to 753.63 kg/m³ and from 1472.42 to 1136.10 kg/m³, respectively (table 3 and 5). The true density of the walnut shells and kernels are generally increased by increasing the moisture content. The effect of moisture content on true density of the walnut shells and kernels was not statistically significant [7].

The volumes of the walnut shells and kernels are presented in (table 3 and 5). The average volumes of the walnut shells and kernels were increased by increasing the moisture content.

Ash content was higher in sample number six (penjwen) which was (2.2%) and lower in sample number ten (Hawramani taxt) which was (0.94%). If the results were compared with the ones previously obtained by Pereira J. et al. (2008) [16], some differences can be observed namely ash content, total oil content (lower in the present work). Its differences could be attributed to the harvesting year and environmental condition, with different temperatures, rainfall and light, which can influence the chemical composition of fruits [14].

Table 2: Measured statistical indices of dimensions and dimensional properties of walnut shells.

sample	L	W	T	G.M.D.	A.M.D.	φ	S	V
Sh1	25.63	23.17	23.01	23.90	23.93	93.27	448.67	7151.04
Sh2	24.98	22.29	22.14	23.10	23.13	92.47	418.91	6451.46
Sh3	24.45	22.17	22.39	22.98	23.00	93.99	414.57	6351.51
Sh4	22.13	19.98	19.26	20.42	20.45	92.27	327.35	4456.68
Sh5	26.19	23.46	23.37	24.30	24.34	92.80	463.75	7514.50
Sh6	23.87	20.36	20.92	21.60	21.71	90.75	368.40	5320.71
Sh7	26.65	23.83	23.13	24.49	24.53	91.89	470.83	7687.32
Sh8	24.76	22.39	22.16	23.07	23.10	93.19	417.94	6429.14
Sh9	25.34	22.91	22.03	23.38	23.42	92.28	429.30	6693.05
Sh10	22.51	20.31	20.76	21.17	21.19	94.05	351.89	4966.96
Sh11	21.89	19.17	18.74	19.88	19.93	90.84	310.42	4115.43
Sh12	27.32	25.56	24.69	25.83	25.85	94.55	523.89	9022.79
Sh13	24.44	22.79	22.27	23.14	23.16	94.71	420.64	6491.48
Sh14	20.11	18.23	17.45	18.56	18.59	92.31	270.51	3347.90
Sh15	23.7	21.38	20.91	21.96	21.99	92.67	378.68	5544.83
mean	24.26	21.86	21.54	22.51	22.55	92.80	401.05	6102.98

Table 3. Physical parameters (weight, volume, true density and moisture content of shell) of walnuts.

Sample	Weight of shell (g)	Volume of shell (cm ³)	True density (kg/m ³)	Moisture content %
Sh1	11.66	16.62	701.56	8.61
Sh2	14.53	19.28	753.63	10.11
Sh3	10.15	15.33	662.10	6.97
Sh4	9.40	14.86	632.57	6.75
Sh5	12.63	17.17	735.58	8.98
Sh6	11.59	16.59	698.61	8.56
Sh7	13.90	18.55	749.32	9.74
Sh8	9.91	15.21	651.54	6.81
Sh9	10.67	15.59	684.41	7.28
Sh10	10.57	15.62	676.69	7.24
Sh11	10.89	15.71	693.18	7.83
Sh12	12.19	16.84	723.87	8.84
Sh13	8.12	13.23	613.75	6.34
Sh14	13.78	18.46	746.47	9.43
Sh15	9.96	15.14	657.85	6.91
mean	11.33	16.28	692.07	8.02

Table 4: Measured the statistical indices of dimensions and dimensional properties of walnut kernels.

sample	l	w	t	G.M.D.	A.M.D.	φ	S	V
K1	20.23	18.41	18.02	18.86	18.88	93.24	279.30	3512.22
K2	19.81	17.57	16.91	18.05	18.09	91.14	255.89	3080.19
K3	18.48	16.39	15.87	16.87	16.91	91.32	223.58	2515.56
K4	17.57	15.82	15.23	16.17	16.20	92.07	205.42	2215.42
K5	20.92	18.62	18.21	19.21	19.25	91.84	289.80	3712.18
K6	18.67	16.35	15.95	16.94	16.99	90.78	225.50	2548.01
K7	21.28	19.06	18.62	19.61	19.65	92.19	302.17	3952.32
K8	20.06	17.91	17.56	18.47	18.51	92.11	268.02	3301.63
K9	20.16	18.33	17.74	18.71	18.74	92.83	274.96	3430.71
K10	18.17	15.98	15.43	16.48	16.52	90.72	213.33	2344.63
K11	17.24	15.19	14.68	15.66	15.70	90.86	192.64	2011.86
K12	21.86	20.01	19.53	20.44	20.46	93.51	328.04	4470.72
K13	19.63	17.46	17.03	18.00	18.04	91.72	254.48	3054.62
K14	17.03	15.11	14.88	15.64	15.67	91.86	192.12	2003.82
K15	18.41	16.37	15.90	16.85	16.89	91.57	223.11	2507.71
mean	19.30	17.23	16.77	17.73	17.766	91.85	248.55	2977.44

Table 5. Physical parameters (weight, volume, true density, percentage yield, moisture content and ash contents) of Kurdistan's walnut kernels.

Sample	Weight of kernel (g)	Volume of kernel (cm ³)	True density (kg/m ³)	Yield of kernel (%)	Moisture content %	Ash content %
K1	5.50	4.367	1259.44	47.16	4.36	2.01
K2	7.40	5.19	1425.81	50.92	5.23	1.28
K3	5.43	4.35	1248.27	53.49	4.28	1.43
K4	4.09	3.60	1136.10	43.51	3.68	2.03
K5	8.01	5.44	1472.42	63.42	5.62	2.08
K6	5.54	4.39	1261.95	47.79	4.44	2.20
K7	6.46	4.77	1354.29	46.47	4.67	2.05
K8	4.36	3.70	1178.37	43.99	3.87	2.03
K9	5.81	4.51	1288.24	54.45	4.59	1.85
K10	6.74	4.88	1381.14	63.79	4.73	0.94
K11	4.53	3.78	1198.41	41.59	3.93	1.72
K12	5.41	4.34	1246.54	44.38	4.21	2.12
K13	4.24	3.63	1168.04	52.21	3.79	1.61
K14	6.47	4.78	1353.55	46.95	4.69	1.32
K15	4.14	3.58	1156.42	41.56	3.74	1.45
mean	5.60	4.35	1275.26	49.44	4.38	1.74

3.2. Total oil content

The extracted oil of walnut kernels was yellowish color [17]. The physicochemical properties of extracted oil are given in table 6. Fat was the highest constitute in all samples, ranging from 36.07% in sikat (sample number 03) to 70.24% in akre (sample number 15). These values were similar to the results reported in Amaral et al., [18] and Yang et al., [19]. Oil contents of this study were lower than those reported by other

[16]. Pereira et al., 2008, reported total oil contents from 78.83 to 82.4%. Variation of total oil % in the walnut samples is presented in table number 6.

Refractive index was determined between 1.4734 (sample number 07 i.e. Qaladze) and 1.4767 (sample number 13 i.e. Ballakayati). In addition, pH-values of kernel oils were measured between 6.23 (sample number 04 i.e. Sharbazher) and 7.02 (sample number 12 i.e. Walzi). The relative density was determined between 0.9746 (sample number 04 i.e. Sharbazher) and 0.9801 (sample number 05 i.e. Sharazur), the result of relative density of all samples was higher than the value reported by Ozcan et al., 2003 [17] for the peanut oil of kernels (0.954-0.955) and also by Ozcan et al., 2004 [20], for terebinth fruit oil (0.9742). Differences between the values of walnut varieties are due to the growing conditions, climatic, environmental conditions and analytic conditions [13].

Table 6. Physical parameter (total oil content, pH, refractive index and relative density of the oils) of walnut kernels.

Sample	Wt. of sample (g) (before extraction)	W t. of sample (g) (after extraction)	Total oil content (%)	pH	RI	Relative density
K1	63.67	40.35	63.37	6.35	1.4750	0.9764
K2	77.88	35.74	45.89	6.40	1.4751	0.9787
K3	75.23	27.14	36.07	6.38	1.4758	0.9798
K4	64.00	35.27	55.10	6.23	1.4759	0.9746
K5	56.78	25.58	45.05	6.67	1.4754	0.9801
K6	58.36	35.00	59.97	6.61	1.4757	0.9753
K7	49.42	29.29	59.26	6.61	1.4734	0.9747
K8	48.49	32.45	66.92	6.45	1.4754	0.9762
K9	59.28	31.89	53.79	6.50	1.4745	0.9775
K10	-----	-----	-----	-----	-----	-----
K11	-----	-----	-----	-----	-----	-----
K12	50.09	25.57	51.04	7.02	1.4748	0.9753
K13	53.46	29.08	54.39	6.95	1.4767	0.9786
K14	42.74	25.58	59.85	6.60	1.4756	0.9749
K15	58.35	40.99	70.24	6.97	1.4738	0.9773
mean	58.28	31.84	55.45	6.59	1.4751	0.9768

4. Conclusions

The study aimed to investigate and evaluate a physicochemical characterization of different walnut samples from different locations to confirm its economical and nutritional quality. There are no significant differences in most of the physicochemical parameters between all studied walnut samples. All investigated types of walnut were acidic and were within the standard limit that indicates freshness of all investigated samples. The differences in physical properties of walnut fruits having about the same size were probably due to the conditions of environmental in conjunction with analytical methods that used [21]. In addition, the moisture content, the ash content and the crude oil contents of walnut fruits are affected mainly by variety and the growth conditions [15]. Finally the present study concludes that the quality and physicochemical properties of walnut shells and kernels in Kurdistan region did not show any considerable significant variations with reference to their physical and chemical properties.

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