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Characteristics and Composition of Watermelon, Pumpkin, and Paprika Seed Oils and Flours

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The nutritional quality and functional properties of paprika seed flour and seed kernel flours of pumpkin and watermelon were studied, as were the characteristics and structure of their seed oils. Paprika seed and seed kernels of pumpkin and watermelon were rich in oil and protein. All flour samples contained considerable amounts of P, K, Mg, Mn, and Ca. Paprika seed flour was superior to watermelon and pumpkin seed kernel flours in content of lysine and total essential amino acids. Oil samples had high amounts of unsaturated fatty acids with linoleic and oleic acids as the major acids. All oil samples fractionated into seven classes including triglycerides as a major lipid class. Data obtained for the oils' characteristics compare well with those of other edible oils. Antinutritional compounds such as stachyose, raffinose, verbascose, trypsin inhibitor, phytic acid, and tannins were detected in all flours. Pumpkin seed kernel flour had higher values of chemical score, essential amino acid index, and in vitro protein digestibility than the other flours examined. The first limiting amino acid was lysine for both watermelon and pumpkin seed kernel flours, but it was leucine in paprika seed flour. Protein solubility index, water and fat absorption capacities, emulsification properties, and foam stability were excellent in watermelon and pumpkin seed kernel flours and fairly good in paprika seed flour. Flour samples could be potentially added to food systems such as bakery products and ground meat formulations not only as a nutrient supplement but also as a functional agent in these formulations.

Keywords: *Watermelon seed; pumpkin seed; paprika seed; oil characteristics; functional properties; nutritional quality*

INTRODUCTION

Recently more attention has been focused on the utilization of food-processing byproducts and wastes, as well as underutilized agricultural products. Obviously, such utilization would contribute to maximizing the available resources and result in the production of various new products for food. At the same time, a major contribution to avoiding waste disposal problems could be made.

The problems of industrial waste are becoming harder to solve, and much effort will be needed to develop the nutritional and industrial potential of byproducts, waste, and underutilized agricultural products. Only a small portion of plant material is utilized directly for human consumption (*1*). The remaining portion of this material or part of it may be converted into nutrients for either food or feed or into fertilizer; thus, an important contribution to food resources or industrial products could be made (*1*, *2*). In this respect, watermelon, pumpkin, and paprika seeds, which remain in large quantities as waste products after the removal of the pulp, peel, and flesh, could be used.

Pumpkin (*Cucurbita* sp.) and melon (*Citrullus* sp.) seeds are utilized directly for human consumption as snacks after salting and roasting in Arabian countries (*3*). These seeds are excellent sources of protein (25.2−37%) and oil (37.8−45.4%) (*4*). Pumpkin seed oil has been produced and sold in the southern parts of Austria, Slovenia, and Hungary (*5*), whereas melon seeds are used for oil production at a subsistence level in Nigeria (*6*). Oils of pumpkin and melon seeds are used as cooking oil in some countries in West Africa and the Middle East (*2*, *7*, *8*). The kernels of pumpkin and melon seeds have been utilized as an additive to some food dishes (*9*). Several reports exist on the nutritive value of proteins and oils of melon and pumpkin seeds (*3*, *4*, *9*, *10*). However, very little information has been reported on the physicochemical and functional properties of pumpkin and melon seed proteins.

Paprika (*Capsicum annuum*) is widely used as flavoring and for nutritional purpose. Paprika seeds are separated from the pods and discarded after eating or processing the flesh. A survey of the literature reveals only one paper reported (*11*) on the fatty acids composition of Hungarian paprika seed oils. No literature data are available on the chemical and physical properties of paprika seed protein.

Therefore, the purpose of this work is to report the chemical composition and other characteristics of oil and protein fractions of both watermelon and pumpkin kernels as well as paprika seeds. In addition, functional properties of seed proteins were also studied.

MATERIALS AND METHODS

Materials. A single batch each of mature fresh watermelon *Citrullus vulgaris* (10 pieces), pumpkin *Cucurbita pepo* (10 pieces), and paprika *Capsicum annuum* (15 kg) were pur-

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chased from the local market (Shibin El-Kom, Egypt) during the summer season of 1998.

Methods. *Preparation of Materials.* Watermelon and pumpkin vegetables were cut with a sharp knife, and the seeds were hand collected from the gourd, washed with tap water, and then sun-dried at ~30 °C for 1 week. Dried seeds were shelled by cracking with a small iron rod and manually peeled to remove the kernels. Paprika seeds were collected by hand after disrupting the paprika pods and subsequently sun-dried at ~30 °C for 1 week. Dried paprika seeds and seed kernels of both pumpkin and watermelon were crushed in an electric mill (Braun, model 1021), then soaked in petroleum ether (bp 40−60 °C) at room temperature (~25 °C), and shaken for 36 h with several changes of solvent (eight times). Evaporation of petroleum ether was performed using a rotary evaporator (ROT. VAC. EVA. RVA. 64, Prague Czech Republic) under vacuum and then performed on a water bath for 1 h; the produced oil samples were stored separately in a refrigerator at 4 °C in dark tightly stoppered glass until analysis. The defatted flours were air-dried at room temperature (~25 °C) for 5 h and then in a vacuum oven (Type SPT-200, vacuum dryer, Kraków, Poland) at 50 °C for 2 h and again ground to pass through a 60 mesh (British standard screen) sieve. The fine flour of each sample was put in an airtight kilner jar and kept in a refrigerator at 4 °C until analysis.

Chemical Analysis. Chemical composition of paprika seed and seed kernels of both watermelon and pumpkin was determined using the following AOAC (*12*) methods: moisture (Method 14.004), total ash (Method 14.006), crude fiber (Method 14.020), total fat (Method 7.056), and total nitrogen (micro-Kjeldahl) (Method 2.057). Protein was calculated as N × 5.3. N-free extract was calculated by difference.

Mineral Contents of Defatted Flours. Samples of defatted flours were digested by concentrated nitric acid and perchloric acid (1:1, v/v). The total phosphorus was determined in the digested solution according to the method of Taussky and Shorr (*13*). Na, Ca, and K were estimated using emission flame photometer (model Corning 410), whereas Mg, Fe, Zn, Mn, and Cu were determined using atomic absorption spectrophotometer (Perkin-Elmer Instrument model 2380).

Amino Acids of Defatted Flours. Amino acids were determined using a Mikrotechna AAA 881 automatic amino acid analyzer according to the method described by Moore and Stein (*14*). Hydrolysis of the flour samples was performed in the presence of 6 M HCl at 110 °C for 24 h under nitrogen atmosphere. Sulfur-containing amino acids were determined after performic acid oxidation as described in the method of Moore (*15*). Meanwhile, tryptophan content was colorimetrically determined according to the method of Miller (*16*) after alkaline hydrolysis.

Antinutritional Factors of Defatted Flours. Trypsin inhibitor activity was estimated according to the method of Kakade et al. (*17*) using benzoyl-DL-arginine-*p*-nitroanalide hydrochloric as substrate. Total tannins (Methods 9.098, 9.099, and 9.100) were determined colorimetrically as described in AOAC (*12*). The Wheeler and Ferrel (*18*) procedure was followed for analysis of phytic acid including determination of phosphorus according to the method of Taussky and Shorr (*13*). Flatulence factors (stachyose, raffinose, and verbascose) were determined according to the report of Tanaka et al. (*19*) using the TLC method.

In Vitro Protein Digestibility of Defatted Flours. This was determined as described by Salgó et al. (*20*) by measuring the change in the sample solution pH after incubation at 37 °C with a trypsin−pancreatin enzyme mixture for 10 min.

Protein Quality of Defatted Flours. Protein quality was determined on the basis of amino acid profiles. Chemical score of amino acids was calculated using the FAO/WHO (*21*) reference pattern. Essential amino acid index was calculated according to the method of Oser (*22*) using the amino acid composition of the whole egg protein published by Hidvégi and Békés (*23*). Protein efficiency ratio (PER) was estimated according to the following regression equation proposed by Alsmeyer et al. (*24*): PER = −0.468 + 0.454 (leucine) − 0.105 (tyrosine).

Physicochemical Characterization of Oils. The specific gravity (using a 10-mL pycnometer at 25 °C), refractive index (using an Abbè refractometer at 25 °C), free fatty acids (Method Ca 5a-40), acid value (Method Cd 3a-63), peroxide value (Method Cd 8-53), saponification value (Method Cd 3-25), and iodine value (Method Cd 1-25) of the oil samples were determined according to AOCS methods (*25*).

Fatty Acids. The methyl esters of crude oil were prepared according to the method of Chalvardjian (*26*), using 1% of H_2SO_4 in absolute methyl alcohol. A Perkin-Elmer gas chromatograph (model F22) with a flame ionization detector at 250 °C was used in the presence of nitrogen as a carrier gas. A glass column (2 m × 2.5 mm) packed with Chrom Q 80/100 mesh at a temperature of 230 °C was used. Standard fatty acid methyl esters of myristic, palmitic, palmitoleic, stearic, oleic, linoleic, and linolenic (Sigma Chemical Co., St. Louis, MO) were used for identification. The area under each peak was measured and the percentage expressed with regard to the total area as mentioned by El-Adawy et al. (*1*).

Lipid Classes. Lipid classes of the crude oils were separated by thin-layer chromatography using precoated plastic sheets (Polygram Sil G, 0.25 mm silica gel) according to the method of Mangold and Malins (*27*). The plate developing solvent system was petroleum ether, diethyl ether, and acetic acid (70:30:2, v/v/v). The fractionated lipid classes were visualized by exposure to iodine vapor in a closed vessel and identified by comparison of R_f values with those reported in the literature (*1*). The quantitative content of each separated fraction type on the plate was measured using the charring desitometry method (*28*), and the area under each peak was measured by triangulation method.

Functional Properties of Defatted Flours. Protein solubility index in distilled water and 1.0 M sodium chloride solution was determined according to the method described by Rahma and Narasinga Rao (*29*). Percentage of protein solubility index was expressed as follows: (percentage of soluble protein/percentage of total protein) × 100. Water and oil absorption capacities were estimated according to the methods of Sosulski (*30*) and Sosulski et al. (*31*), respectively, and expressed as grams of water or milliliters of sunflower oil bound per gram flour. Foam capacity and foam stability were assessed according to the method of Lawhon et al. (*32*) using 1% protein solution in a Bruan blender at 1600 rpm for 5 min. The percentage increase in foam volume was recorded as foam capacity. The change in volume of foam after 15, 30, 45, and 60 min of standing at room temperature (~30 °C) was recorded as foam stability. Emulsification capacity (milliliters oil per gram of protein) was determined as described by Beuchat et al. (*33*). Emulsifying activity and emulsion stability were estimated according to the method of Yasumatsu et al. (*34*). Briefly, 10 mL of sunflower oil was added to 10 mL of protein solution (10%) and homogenized for 2 min in Bruan blender at 7000 rpm. The emulsion was then divided evenly into two 12-mL centrifuge tubes and centrifuged at 2000*g* for 5 min. Emulsifying activity was expressed as follows: (height of emulsified layer/the height of total contents in the tube) × 100. Emulsion stability was determined by centrifugation after heating at 80 °C for 30 min and was expressed as follows: (height of emulsified layer after heating/the height of total contents in the tube) × 100.

Statistical Analysis. Results are expressed as the mean value ± SD of three separate determinations, except for the amino acid and fatty acid contents, which were determined in duplicate. The data were statistically analyzed using analysis of variance (ANOVA) and least significant difference using SAS (*35*). Significant differences between any two means were determined at the $P \leq 0.05$ level.

RESULTS AND DISCUSSION

Chemical Composition. Proximate compositions of watermelon and pumpkin seed kernels and paprika seed are presented in Table 1. Significant ($P \leq 0.05$) differences were observed among paprika seeds and seed

Table 1. Chemical Composition of Watermelon and Pumpkin Seed Kernels and Paprika Seed (Grams per 100 g of Dry Weight Sample)[a]

component	watermelon seed kernel	pumpkin seed kernel	paprika seed
crude protein	35.66[b] ± 0.44	36.47[a] ± 0.48	24.43[c] ± 0.33
crude oil	50.10[b] ± 0.31	51.01[a] ± 0.28	25.61[c] ± 0.28
crude fiber	4.83[b] ± 0.63	4.43[b] ± 0.59	34.91[a] ± 0.75
total ash	3.60[b] ± 0.14	3.21[c] ± 0.16	4.32[a] ± 0.17
N-free extract[b]	5.81[b] ± 0.53	4.88[c] ± 0.42	10.73[a] ± 0.51

[a] Means ± standard deviation of three determinations. Means in the same row with different letters are significantly different ($P \leq 0.05$). [b] By difference.

Table 2. Mineral Composition of Watermelon and Pumpkin Seed Kernel Flours and Paprika Seed Flour (Milligrams per 100 g of Dry Weight Flour)[a]

element	watermelon seed kernel flour	pumpkin seed kernel flour	paprika seed flour
copper	2.1[b] ± 0.15	1.7[c] ± 0.13	3.7[a] ± 0.15
zinc	10.6[a] ± 0.34	8.2[b] ± 0.31	6.7[c] ± 0.25
iron	12.1[b] ± 0.44	10.9[c] ± 0.43	14.6[a] ± 0.46
manganese	9.9[a] ± 0.24	8.9[b] ± 0.28	7.2[c] ± 0.22
magnesium	542[a] ± 6.70	483[b] ± 5.65	396[a] ± 5.17
sodium	33[b] ± 1.49	38[a] ± 1.80	37[a] ± 1.38
calcium	150[b] ± 3.15	130[c] ± 2.57	163[a] ± 4.26
potassium	1176[b] ± 10.42	982[c] ± 8.84	1214[a] ± 12.25
phosphorus	1279[a] ± 9.59	1090[b] ± 9.60	989[c] ± 7.65

[a] Means ± standard deviation of three determinations. Means in the same row with different letters are significantly different ($P \leq 0.05$).

kernels of both pumpkin and watermelon in their content of protein, oil, fiber, ash, and N-free extract. Kernels of watermelon and pumpkin have high levels of protein (35.66−36.47%) and oil (50.10−51.01%); however, paprika seeds were still higher than many legumes in their protein (24.43%) and oil (25.91%) contents. This finding may focus the interest of using paprika seeds and seed kernels of both pumpkin and watermelon as high protein and oil sources in some food formulations. Paprika seeds had higher amounts of crude fiber (34.91%) and N-free extract (10.37%) than seed kernels of pumpkin and watermelon. Therefore, paprika seeds could be also considered as a good source of dietary fiber.

Minerals. Mineral contents of watermelon and pumpkin seed kernel flours and paprika seed flour are shown in Table 2. Paprika seed flour has significantly ($P \leq 0.05$) higher potassium, calcium, copper, and iron contents than pumpkin and watermelon seed kernel flours, whereas watermelon seed kernel flour has significantly ($P \leq 0.05$) more phosphorus, magnesium, manganese, and zinc. However, all flours contained considerable amounts of minerals, but only a low amount of copper was present. All flours are good sources of phosphorus, potassium, magnesium, manganese, and calcium. Generally, these results were in good agreement with those reported by Lazos (*4*) for pumpkin and watermelon seeds. However, no literature data were found regarding mineral contents of paprika seed flour. Because some wheat flours in the baking industry are deficient in some elements, in particular, calcium and iron (*36*), the fortification of wheat flours with paprika seed flour as well as pumpkin and watermelon seed kernel flours might improve their dietary properties.

Amino Acid Composition. Amino acid compositions of watermelon and pumpkin seed kernel flours and paprika seed flour are shown in Table 3. The amino acid profiles of watermelon and pumpkin seed kernel flours were either similar or only slightly different. However, paprika seed flour is rich in total essential amino acids, lysine, threonine, total aromatic amino acids, and tryptophan as compared with the FAO/WHO (*21*) reference pattern and both watermelon and pumpkin seed kernel flour profiles. Paprika seed flour had lower levels of isoleucine, valine, sulfur-containing amino acids, and leucine as compared with the reference pattern. However, it is interesting that the paprika seed protein could complement well only with protein sources low in lysine and tryptophan. No publications were found regarding the amino acid profile of paprika seed protein. Watermelon seed kernel flour had higher levels of leucine, total aromatic amino acid, and tryptophan, whereas both watermelon and pumpkin seed kernel flours had lower levels of lysine and leucine as compared with the FAO/WHO (*21*) reference pattern. Therefore, these seed kernel flours require supplementation with complementary protein if these seed kernel proteins are used as food sources. The earlier studies of Nwokolo and Sim (*9*) reported that watermelon and pumpkin seed kernel flours are superior to soybean in their contents of all amino acids except lysine, which is in contrast to our findings.

Table 3. Amino Acid Composition of Watermelon and Pumpkin Seed Kernel Flours and Paprika Seed Flour (Grams per 16 g of Nitrogen)[a]

amino acid (AA)	watermelon seed kernel flour	pumpkin seed kernel flour	paprika seed flour	FAO/WHO (1973)
isoleucine	2.80	3.21	3.89	4.0
leucine	7.70	6.49	5.03	7.0
lysine	3.14	4.17	8.18	5.5
cystine	1.39	1.17	1.67	
methionine	1.71	1.88	1.03	
total sulfur AA	3.10	3.05	2.70	3.5
tyrosine	3.92	3.17	3.59	
phenylalanine	5.76	4.47	4.69	
total aromatic AA	9.68	7.64	8.28	6.0
threonine	3.09	3.30	5.10	4.0
tryptophan	1.15	0.86	1.22	1.0
valine	3.98	4.71	4.45	5.0
total essential AA	34.63	33.43	38.85	36.0
histidine	3.21	3.26	1.48	
arginine	18.58	19.03	8.65	
aspartic acid	8.09	9.61	14.46	
glutamic acid	15.63	17.33	15.86	
serine	5.01	5.41	6.17	
proline	4.12	3.37	4.82	
glycine	5.66	4.32	4.39	
alanine	5.07	4.24	5.32	
total nonessential AA	65.57	66.57	61.15	

[a] Average of two determinations.

Fatty Acid Composition. Table 4 shows the fatty acid composition of crude oils of watermelon and pumpkin seed kernels and paprika seeds. There were wide variations in the contents of palmitic, stearic, oleic, and linoleic acids among the oils studied, leading to differences in total saturated, total unsaturated, monounsaturated, and polyunsaturated fatty acid. All oil samples had high amounts of total unsaturated fatty acids (which consisted mainly of linoleic followed by oleic and palmitoleic acid) representing 78.35% for watermelon seed kernel oil, 76.46% for pumpkin seed kernel oil, and

Table 4. Fatty Acid Composition (Percent) of Watermelon and Pumpkin Seed Kernel Oils and Paprika Seed Oil[a]

fatty acid (FA)	watermelon seed kernel oil	pumpkin seed kernel oil	paprika seed oil
myristic ($C_{14:0}$)	0.11	0.17	
palmitic ($C_{16:0}$)	11.30	13.41	13.84
palmitoleic ($C_{16:1}$)	0.29	0.44	0.12
stearic ($C_{18:0}$)	10.24	9.96	3.71
oleic ($C_{18:1}$)	18.07	20.38	14.56
linoleic ($C_{18:2}$)	59.64	55.64	67.77
linolenic ($C_{18:3}$)	0.35		
total unsaturated FA (TUSFA)	78.35	76.46	82.45
total saturated FA (TSFA)	21.65	23.54	17.55
monounsaturated FA (MUSFA)	18.36	20.82	14.68
polyunsaturated FA (PUSFA)	59.99	55.64	67.77

[a] Average of two determinations.

Table 5. Percentage of Lipid Classes of Watermelon and Pumpkin Seed Kernel Oils and Paprika Seed Oil

lipid class	watermelon seed kernel oil	pumpkin seed kernel oil	paprika seed oil
hydrocarbons	0.27[c] ± 0.12	0.62[b] ± 0.11	0.97[a] ± 0.12
triglycerides	94.90[a] ± 0.45	94.52[ab] ± 0.39	94.16[b] ± 0.38
free fatty acids	1.41[a] ± 0.11	1.44[a] ± 0.13	1.48[a] ± 0.12
sterols	1.12[a] ± 0.12	1.01[a] ± 0.11	0.89[b] ± 0.08
diglycerides	0.35[a] ± 0.10	0.39[a] ± 0.12	0.30[a] ± 0.11
monoglycerides	0.98[a] ± 0.11	0.93[a] ± 0.10	1.35[b] ± 0.11
phospholipids	0.96[ab] ± 0.13	1.09[a] ± 0.12	0.85[b] ± 0.14

[a] Means ± standard deviation of three determinations. Means in the same row with different letters are significantly different ($P \leq 0.05$).

82.45% for paprika seed oil. Paprika seed oil had the highest content of linoleic acid (67.77%) and the lowest amount of oleic acid (14.56%) compared to the other kernel oils. The presence of high amounts of the essential fatty acid linoleic acid suggests that these oils are highly nutritious oils due to the ability of unsaturated vegetable oils to reduce serum cholesterol (*10*). As all of the oil samples examined are rich in both oleic and linoleic acids, they may be used as edible cooking oil, as salad oil, or for the manufacture of margarine. The major saturated fatty acids in crude oils of paprika seed and seed kernels of both watermelon and pumpkin were palmitic and stearic acids. The total saturated fatty acid contents of watermelon and pumpkin seed kernels were higher (21.65 and 23.65%) than that in paprika seed oil (17.55%). These results are confirmed by the findings of Al-Khalifa (*3*) for pumpkin and watermelon seed oils and Domokos et al. (*11*) for Hungarian paprika seed oils.

Lipid Classes. The quantitative data of the individual lipid classes of crude oils of paprika seed and seed kernels of watermelon and pumpkin are shown in Table 5. Crude oils of paprika seeds and seed kernels of watermelon and pumpkin contained seven lipid classes, which appeared on the thin-layer chromatogram in the following sequence order from the front to the baseline: hydrocarbon, triglycerides, free fatty acids, steroids, diglycerides, monoglycerides, and phospholipids. Triglycerides were predominant lipid class in all oil samples (representing 94.16, 94.90, and 94.52% for crude oils of paprika seed and seed kernels of both watermelon and pumpkin, respectively), followed by free fatty acids and then monoglycerides. Free fatty acids, monoglycerides, and hydrocarbon contents were high in paprika seed oil, but triglyceride and phospholipid contents were high in watermelon and pumpkin seed kernel oils. The presence of monoglycerides and free fatty acids in oil samples may be due to the partial enzymatic hydrolysis of reserve triglycerides during storage of the seeds. Aboul-Nasr et al. (*37*) reported that triglycerides were the major lipid fraction in pumpkin seed oil. No data in the literature on the lipid classes of paprika and watermelon seed oils were available for comparative purposes.

Physicochemical Properties of Crude Oils. Some of the chemical and physical properties of the crude oils extracted from watermelon and pumpkin seed kernels and paprika seed are shown in Table 6. The specific gravity of paprika seed oil was lower than that of watermelon and pumpkin seed kernel oils, and the values compared well with the 0.915 and 0.928 values reported by Kamel et al. (*38*) for watermelon oil and by Al-Khalifa (*3*) for pumpkin oil, respectively. All oil samples had higher iodine values compared to some citrus seed oils (*1*), thus reflecting a high degree of unsaturation. Saponification values were higher (except paprika seed oil) than those reported in the literature for cottonseed oil (189−198) but lower than those for coconut oil (248−265) (*39*). Peroxide values, acid values, and free fatty acids of all oil samples were similar. The Codex Alimentarius Commission (*39*) stipulated a permitted maximum peroxide level of not more than 10 mequiv of peroxide oxygen/kg of oil, for example, soybean, cottonseed, rapeseed, and coconut oils. It also stipulated permitted maximum acid values of 10 and 4 mg of KOH/g of oil for virgin palm oil and coconut oil, respectively. The values of refractive index and ester number of watermelon and pumpkin seed oils were comparable to those reported by Al-Khalifa (*3*), Lazos (*4*), and Badifu (*40*). It is worthwhile to indicate that there are no data in the literature of the chemical and physical properties of paprika seed oil for comparative results.

Antinutritional Factors. Antinutritional factors of watermelon and pumpkin seed kernel flours as well as paprika seed flour are shown in Table 7. No significant

Table 6. Physicochemical Characteristics of Watermelon and Pumpkin Seed Kernel Oils and Paprika Seed Oil[a]

property	watermelon seed kernel oil	pumpkin seed kernel oil	paprika seed oil
refractive index (25 °C)	1.4696[a] ± 0.001	1.4706[a] ± 0.001	1.4715[b] ± 0.001
specific gravity (25 °C)	0.919[a] ± 0.007	0.917[a] ± 0.006	0.912[a] ± 0.007
acid value (mg of KOH/g of oil)	2.82[a] ± 0.15	2.88[a] ± 0.18	2.96[a] ± 0.16
saponification value (mg of KOH/g of oil)	201[b] ± 2.25	206[a] ± 2.56	168[c] ± 1.90
ester value (mg of KOH/g of oil)	193.58[b] ± 3.15	203.12[a] ± 3.28	165.04[c] ± 3.25
iodine value (g of I/100 g of oil)	115[b] ± 3.36	109[c] ± 2.29	131[a] ± 3.49
peroxide value (mequiv of O_2/kg of oil)	3.40[a] ± 0.38	3.60[a] ± 0.41	3.21[a] ± 0.35
free fatty acid (% as oleic acid)	1.41[a] ± 0.11	1.44[a] ± 0.13	1.48[a] ± 0.12

[a] Means ± standard deviation of three determinations. Means in the same row with different letters are significantly different ($P \leq 0.05$).

Table 7. Antinutritional Factors of Watermelon and Pumpkin Seed Kernel Flours and Paprika Seed Flour (Grams per 100 g of Dry Weight Flour)[a]

antinutritional factor	watermelon seed kernel flour	pumpkin seed kernel flour	paprika seed flour
raffinose	$0.32^{b} \pm 0.15$	$0.29^{b} \pm 0.13$	$0.79^{a} \pm 0.15$
stachyose	$0.67^{ab} \pm 0.21$	$0.52^{b} \pm 0.19$	$0.92^{a} \pm 0.29$
verbascose	$0.26^{b} \pm 0.11$	$0.23^{b} \pm 0.10$	$0.66^{a} \pm 0.21$
phytic acid	$2.63^{a} \pm 0.33$	$2.37^{a} \pm 0.29$	$1.98^{b} \pm 0.18$
tannins	$0.24^{b} \pm 0.08$	$0.17^{b} \pm 0.09$	$0.48^{a} \pm 0.12$
trypsin inhibitor (TIU/mg of protein)	$1.46^{b} \pm 0.21$	$1.39^{b} \pm 0.19$	$1.96^{a} \pm 0.23$

[a] Means ± standard deviation of three determinations. Means in the same row with different letters are significantly different ($P \leq 0.05$).

Table 8. In Vitro Protein Digestibility and Estimated Quality of Watermelon and Pumpkin Seed Kernel Flours and Paprika Seed Flour

method of evaluation	watermelon seed kernel flour	pumpkin seed kernel flour	paprika seed flour
in vitro protein digestibility (%)	$87.91^{b} \pm 1.23$	$90.01^{a} \pm 1.27$	$72.65^{c} \pm 1.10$
chemical score % (CS)	57.09	75.82	71.86
1st limiting AA	lysine	lysine	leucine
2nd limiting AA	isoleucine	isoleucine	Cys + Met
essential AA index (EAAI)	58.84	85.41	67.28
protein efficiency ratio (PER)	2.62	2.15	1.44

[a] Means ± standard deviation of three determinations. Means in the same row with different letters are significantly different ($P \leq 0.05$).

($P \geq 0.05$) differences were found between watermelon and pumpkin seed kernel flours in their content of antinutritional factors. However, significant ($P \leq 0.05$) difference was observed between paprika seed flour and both watermelon and pumpkin seed kernel flours in their contents of antinutritional factors. The highest level of phytic acid was noticed in pumpkin and watermelon seed kernel flours (2.37 and 2.63 g/100 g of sample, respectively), whereas the highest levels of tannins (0.48 g/100 g of sample), trypsin inhibitor (1.96 TIU/mg of protein), raffinose (0.79 g/100 g of sample), stachyose (0.92 g/100 g of sample), and verbascose (0.66 g/100 g of sample) were found in paprika seed flour. Tannins and trypsin inhibitor activity content of all flour samples were lower than those reported by Rahma et al. (*41*) for faba bean (1.68%) and by Mansour and El-Adawy (*42*) for fenugreek seeds (6.02 TUI/mg of sample), respectively. However, phytic acid content was higher than that reported by Khalil and El-Adawy (*43*) for white bean flour (1.31%). To the best of our knowledge there are no data reported in the literature with regard to the antinutritional factors in watermelon, pumpkin, and paprika seed flours.

In Vitro Protein Digestibility and Protein Quality. In vitro protein digestibility and biological values of watermelon and pumpkin seed kernel flours as well as paprika seed flour are shown in Table 8. In vitro protein digestibility was significant ($P \leq 0.05$) different among all flours. Pumpkin seed kernel flour had the highest in vitro protein digestibility (90.01%) followed by watermelon seed kernel flour (87.91%) and then paprika seed flour (72.65%). The low digestibility in paprika seed flour could be attributed to their higher contents of trypsin inhibitor and tannins than other flours. Aw and Swanson (*44*) found that tannins adversely affect the nutritive value of black beans by decreasing the proteolytic enzymes' digestibility. Oyenuga and Fetuga (*45*) found the in vitro protein digestibility of melon seed protein to be in the range 91−93%, which is comparable to that of soybean meal but less than whole hen's egg protein (98.8%).

Estimated protein quality depends, in large measure, on the relative proportions of the essential amino acids (*1*). On the basis of chemical score, the first and second limiting amino acids were lysine and isoleucine, respectively, for seed kernel flours of watermelon and pumpkin, whereas these were leucine and total sulfur amino acids, respectively, for paprika seed flour. Kamel et al. (*2*) reported that the first limiting amino acid was lysine in watermelon seed flours. It would be interesting to attempt to improve and increase the protein quality of wheat flour (which is limited in lysine) through blending with paprika seed flour. However, paprika seed flour had lower a protein efficiency ratio (PER) and a higher essential amino acid index (EAAI) than both watermelon and pumpkin seed kernel flours.

Functional Properties. Table 9 shows the functional properties of watermelon and pumpkin seed kernel flours and paprika seed flour. Nonsignificant ($P \geq 0.05$) difference was observed among flour samples in their protein solubility index in distilled water and 5% sodium chloride. However, the protein solubility index of all flour samples in sodium chloride was higher than that in distilled water. This could be due to the fact that distilled water extracts only albumin, whereas sodium chloride extracts and solublizes albumin and

Table 9. Functional Properties of Watermelon and Pumpkin Seed Kernel Flours and Paprika Seed Flour

functional property	watermelon seed kernel flour	pumpkin seed kernel flour	paprika seed flour
protein solubility index (%) in			
distilled water	$23.91^{a} \pm 2.41$	$24.26^{a} \pm 2.30$	$24.87^{a} \pm 2.29$
sodium chloride (5%)	$78.03^{a} \pm 2.62$	$79.70^{a} \pm 2.43$	$78.78^{a} \pm 2.51$
water absorption capacity (g of H_2O/g of flour)	$2.55^{a} \pm 0.12$	$2.51^{a} \pm 0.15$	$2.10^{b} \pm 0.14$
fat absorption capacity (mL of oil/g of flour)	$3.89^{a} \pm 0.15$	$3.85^{a} \pm 0.12$	$3.10^{b} \pm 0.16$
emulsification capacity (mL of oil/g of protein)	$98.20^{a} \pm 2.50$	$98.50^{a} \pm 2.71$	$51.20^{b} \pm 2.10$
emulsification stability (%)	$44.10^{a} \pm 1.95$	$43.90^{a} \pm 1.92$	$18.60^{b} \pm 1.30$
emulsification activity (%)	$60.00^{a} \pm 3.45$	$59.20^{a} \pm 3.55$	$41.70^{b} \pm 3.21$
foam capacity (% vol increase)	$18.12^{a} \pm 1.85$	$18.65^{a} \pm 2.10$	$12.75^{b} \pm 2.21$
foam stability (mL) at			
15 min	$15.20^{a} \pm 1.3$	$15.90^{a} \pm 1.4$	$10.50^{b} \pm 1.2$
30 min	$12.80^{a} \pm 1.1$	$13.50^{a} \pm 1.3$	$8.40^{b} \pm 1.2$
45 min	$9.90^{a} \pm 1.2$	$10.10^{a} \pm 1.3$	$6.10^{b} \pm 1.1$
60 min	$8.50^{a} \pm 1.1$	$8.60^{a} \pm 1.2$	$5.50^{b} \pm 1.2$

[a] Means ± standard deviation of three determinations. Means in the same row with different letters are significantly different ($P \leq 0.05$).

globulin. Watermelon and pumpkin seed kernel flours had significantly ($P \leq 0.05$) higher water and fat absorption capacities, emulsification properties, and foam capacity than paprika seed flour. All flour samples absorb more fat than water. However, the water absorption capacity of flour samples was quite high compared to that of other vegetable proteins (0.81 g of H_2O/g of faba bean flour) (*41*). These two properties may give an advantage to the use of these flours in some bakery products, as meat replacers, and as thickening agent in soups. Emulsification properties (capacity, stability, and activity) of watermelon and pumpkin seed kernel flours were fairly high compared to the other vegetable proteins (*46*), which may be of interest in sausage and other comminuted meat products. The foaming properties of the flour samples were poor, and this may be due to the lower solubility of the flour proteins in water at natural pH. Therefore, addition of sodium chloride to water may improve the foaming properties of these flours because it increases the ionic strength of water and solublized protein.

Conclusion. Watermelon and pumpkin seed kernels and paprika seed could be utilized successfully as sources of edible oils and protein for human consumption. In addition, paprika seed could be considered as a good source of dietary fiber.

Because of their high content of unsaturated fatty acids, watermelon, pumpkin, and paprika seed oils might be acceptable substitutes for highly unsaturated oils.

Seed kernel flours of watermelon and pumpkin as well as paprika seed flour have great potential for addition to food systems, not only as nutrient supplements but also as a functional agent.

Finally, the utilization of these seeds for oil and protein production could provide extra income and at the same time help to minimize waste disposal problems.

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