Functional properties of Watermelon (Citrullus lanatus) and Pumpkin seed flours and protein isolate

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Abstract

The current study was intended to evaluate the chemical composition, functional properties, of some cucurbits seed. watermelon *(Citrullus lanatus*), and Pumpkin (*Cucurbita maxima)*, were studied. Proximate analysis gave 17.09% -17.07% protein, 35.55%-39.0% fat,6.00% - 5.5% total ash, 24.9%-2.6% crude fibre, and 10.60% - 28.83% carbohydrate, for Pumpkin and Watermelon seed flour respectively. The seeds are rich in protein, crude fat, and crude fiber. nutritional value in the seed can be recommended on daily allowance, maintenance of good nutritional status and good health. The functional properties of the seed revealed that water and oil absorption capacities for the seed were 3.20 - 5.60 (Ml/g) and 3.93 -3.50 (Ml/g) for Watermelon and Pumpkin seed flour respectively. Foam capacity and bulk density for the seed were 9.67 % -19.0 % and 0.77 (g/ml) -1.5 (g/ml). for Pumpkin and Watermelon seed flour respectively. Water and fat absorption capacities, and foam capacity were fairly good in all seeds. However, Pumpkin seed flour gave good functional properties compare to watermelon seed flour. The oil of watermelon and Pumpkin are acceptable according to its chemical properties. The seeds contained high amounts of K, Mg, Na, P and Ca. The obtained results revealed that the seeds presented an alternative source of vegetable oil. Seeds could be added to food systems such as bakery products.

Research Article
Open Access &
Peer-Reviewed Article
DOI: 10.14302/issn.2379-7835.ijn-22-4377

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Keywords:
watermelon, Pumpkin, functional properties, chemical composition.

Received: Nov 16, 2022
Accepted: Mar 16, 2023
Published: Mar 30, 2023

Academic Editor:
Ian James Martins, PRINCIPAL RESEARCH FELLOW Edith Cowan University.

Citation:
Ikhlas Ibrahim Khalid (2023) Functional properties of Watermelon (Citrullus lanatus) and Pumpkin seed flours and protein isolate. International Journal of Nutrition - 7 (3):4-15. https://doi.org/10.14302/issn.2379-7835.ijn-22-4377

Introduction

Plant protein play a significant role in human nutrition. In developing countries where average protein intake is less than required plant protein is needed such as ground nut, coconut, soybean and cotton seed are suggested. Cucurbit seeds from Cucurbitaceae plants (squashes, pumpkins, melons, etc.) have been used as protein-rich food ingredients. **Watermelon** (*Citrullus lanatus*) is of the cucurbitaceae family, related to the cantaloupe, squash and pumpkin **[1]**. Cucurbit seeds are source of food particularly protein and oil [2].

Watermelon is an important crop grown in tropical regions of the world. Its propagation requires a temperature of over 25 °C and thrives best in fairly acidic and drained fertile soil **[3].** Watermelon seeds represent a multi-purpose crop, they are consumed in the rural areas in the form of various food stuffs and in the form of fried seeds sold as a cash crop all over the Sudan. For industrial consumption, oil from watermelon seed is mainly used as cooking oil in the Sudan. The seeds of watermelon contain phyto chemicals such as saponins, alkaloids, phenols, flavonoids and tannins which have antioxidant, anti-inflammatory, antimicrobial, anti-infection and anticancer properties [4], [5].The nutritional values of Watermelon seeds are favorably well compared to soybean, sunflower and ground nuts, [6], [7], [8], [9]. The watermelon seeds are rich sources of proteins, vitamins B, minerals such as magnesium, potassium, phosphorous, sodium, iron, zinc, manganese, copper. and lipid, fibre and carbohydrates, The fibre content of the fruits and vegetables has been investigated to have beneficial effects on blood cholesterol and they prevent large bowel diseases,[10].In Sudan water melon is used mainly as watery juice in many dry areas specially in Darfur and Kordofan region as a water substitute for man and animals , especially, during the dry season, watermelon seed oil has advantage of containing low amount of saturated fatty acids which can benefit patients with cardio vascular disease. [11], [12]. Plant proteins should possess desirable functional properties and provide essential amino acids for their utilization in different food systems. [13].

Pumpkin belongs to the family cucrbitaceae, most of which are tendril climbing herbaceous annuals containing some extremely well known edible fruits such as pumpkin, squash, cucumber, musk-melon, and watermelon [14]. Pumpkin plant grows in warm humid and sometime humid regions, and cannot withstand frost. The varieties in Sudan probably belong to Cucurbita moschata (Qara assally) as stated by [15]. The genus cucurbita includes Cucurbita pepo, Cucurbita moschata, Cucurbita maxima, Cucurbita mixta, and Cucurbita toxana. In Sudan pumpkin brings a good market price and could be shipped for long distances with little damage [16]. In Sudan the pumpkin seeds are considered as a by-product. Little amounts are eaten after being salted and roasted (Tasali), or exported together with watermelon seeds to Egypt. The seeds are considered as a good source of oil, pumpkin seeds contain higher oil content value (51.8%) pumpkin seeds are good source of protein and minerals such as iron and phosphorous. In many developing countries, the supply of animal protein is inadequate to meet the protein needs of the rapidly growing population. Research efforts geared towards the study of the food properties and potential utilization of protein from locally available food crops. In Sudan pumpkin seeds are partially utilized by direct consumption but large quantities are wasted [17].

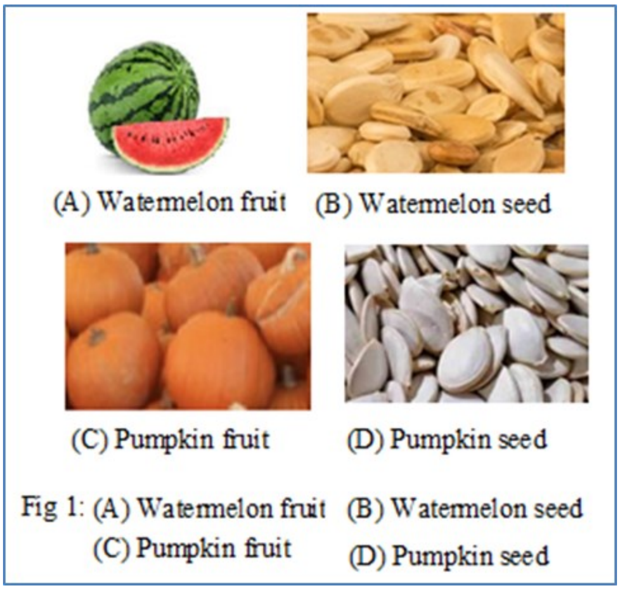

Figure 1. (A) Watermelon fruit, (B) Watermelon seed, (C) Pumpkin fruit, (D) Pumpkin seed

The purpose of this investigation is to study the functional properties of watermelon and pumpkin seeds flour.

Material and methods

Materials

Watermelon (*Citrullus Lanatus*) and pumpkin *Cucurbita moschata* seeds (Figure 1) were obtaine from Wad Medani town local market for vegetables Sudan.

Preparation of Samples

The seeds of both sample (Watermelon and Pumpkin) were freshly cleaned by removing the sand and foreign materials, washed with running tap water and then dried in the oven at 60^0 C for 24 hours and were powdered with mechanical grinder and mortar, packaged and stored in refrigeration at about 4^0C until used.

Proximate chemical composition

The proximate composition was determined using AOAC, [18] methods**.** Protein (Kjeldahl), fat (Soxhlet), carbohydrates, by differences moisture and ash (gravimetrically) and crude fibre by a chemical-gravimetric and the means reported on dry weight basis. All the analysis was performed in triplicate.

Minerals

Minerals of raw samples were extracted according to the method described by [19]**.** Seeds flour samples were digested by concentrated HNO_3 and $HCLO_4$ (1:1, V/V) for 2 hours (till solution became colorless). **Na, Ca and K** were estimated using emission flame photometer (Model Corning 410). .

Chemical analysis of oils

Free fatty acids or acid value (AV), the peroxide value (PV) and Saponification value (SV) was determined according to [20]**.**

Functional properties

Water and oil absorption capacity

WAC and FAC were determined according to the method described by [21] The water and oil absorption capacity were calculated as follows:

$$\frac{\text{Volume of water or oil added to the sample} - \text{Volume of free water or oil}}{\text{Weight of the sample taken}}$$

Foaming properties

FC and FS at different pH levels were determined by the method described by [22] with slight modification. 1 g of each samples of watermelon and pumpkin seed flour were whipped with 100 ml distilled water for 5 min at the highest speed at room temperature.

The contents along with foam were immediately poured into a 250 ml measuring cylinder. The volume of foam (ml) at 30 seconds was calculated, and the volume increase is expressed as % FC.

$$\text{FC}(\%) = \frac{\text{Volume of the foam after whipping (ml)}}{\text{volume of the foam before whipping (ml)}} \times 100$$

Foam stability (FS)

Determined by measuring the decrease in volume of foam as a function of a time up to period of 120 min, the stable foam volumes were recorded at time intervals of 5, 10, 15, 20, 30, 40, 50, 60, 90 and 120 min.

$$FS\ (\%) = \frac{\text{Foam volume after time(t)} \times 100}{\text{Initial foam volume (t)}}$$

Where: t_0 = the starting time immediately after blending.

t= the time at which the foam volume is increase.

The FC and FS at room temperature were determined as the function of pH of the products. The pH was adjusted to desired value (2, 4, 7, 9, and 12) with either 1 or 0.1 N NaOH prior to whipping.

Emulsifying properties:

Emulsifying capacity and emulsion stability were determined by the turbidmetric method as described by [23]: Emulsifying capacity was also determined in the pH range of 1-12 (2, 4, 7, 9 and 12) using 1 N HCl or I N NaOH solution.

Emulsifying capacity was calculated as follows:

$$\text{Emulsifying capacity} = \frac{\text{Weight of oil emulsified}}{\text{Weight of sample taken}}$$

Where:

Weight of oil emulsified=Total volume of oil emulsified×specific gravity of oil used

Gelation capacity

Least gelation concentration was determined using the method described by [24]

Statistical analysis

Data, based on three replicates, subjected to analysis of variance by complete block design [25] [26] Standard deviation evaluated. Least significance difference (LSD) mean computed and variations at 5% level; probability (P = 0.05).

Results and discussion

Proximate composition:

Results of proximate composition of the seed flour of Watermelon and Pumpkin are presented in Table 1. Watermelon and pumpkin contain 17.07 - 17.09 30% protein; 39.00 - 35.55% fat ; 2.6 - 24.9% fiber ;5.5 -6.03 % ash and 28.83 - 10.60% carbohydrates, respectively (on dry weight basis). as major components.

The result of **moisture content** of watermelon seeds (7.0%), was higher than that reported by Mustafa *et al* [27]. reported 4.94% for type obtained from kordufan, and slightly similar to that reported by Ogunsua *et al* [28].of two Nigerian varieties (7.9% and 5.6% respectively.). Sudanese watermelon seeds obtained from western Sudan is 2.8% as determined by Yousuf, [29]. The differences could be attributed to methodology, soil, storage and variety. **ash content** of watermelon was found to be higher than that reported by several workers, **Mustafa et al.** [27].,; **Ogunsua et al.,** [28].; **Lasztity et al.,**

Table 1. Proximate composition Watermelon, and pumpkin seed flour (on dry basis)

Cucurbit	Moisture %	Ash	Protein %	Fat %	Fiber%	CHO%
Pumpkin	5.85 ± 0.15[b]	6.03±0.16[a]	17.08±0.09[b]	35.55±0.	24.9±0.12[a]	10.60±0.60[a]
Watermelon	7.0 ± 0.01[a]	5.5 ± 0.14[b]	17.09 ±0.05[b]	39.00±0.	2.6±0.04[b]	28.83 ±1.70[b]

Means ± standard deviation of three replicates. Means in the same raw with different letters are significantly different (P < 0.05). LSD = Least significant for differences.

Table 2. Chemical characteristics of oil content Watermelon, and pumpkin seed flour

Cucurbit seeds	Oil %	Acid value (ml/gm.)	Peroxide value *meq/kg* (O_2/kg oil)	Saponification value	Free fatty acid %
Pumpkin	38.60± 018 [a]	2.50 ±0.06 [a]	5.50 ±0.02[a]	150.40 ± 03. [a]	1.20 ± 0.04 [a]
Watermelon	27.09 ± 0,05 [b]	2.40± 0.04[a]	1. 91±0.0[b]	180.70± 0.42 [b]	1.18± 0.03[a]

Means ± standard deviation of three replicates. Means in the same raw with different letters are significantly different (P < 0.05). LSD = Least significant for differences.

Table 3. Mineral content in Watermelon, and pumpkin seeds (mg/100 g).

Cucurbit seeds	Ca	Mg	Na	K	P
Pumpkin	2.35± 0.16 [b]	0.23± 0.11 [b]	0.30 ± 0.14 [b]	14.0±0.23 [b]	1.0± 0.12 [a]
Watermelon	3.08± 0.11 [a]	1.22±0.14[a]	0.80± 0.05 [a]	12.01±0.08 [a]	0.50 ± 0.02 [b]

Means ± standard deviation of three replicates. Means in the same raw with different letters are significantly different (P < 0.05). LSD = Least significant for differences.

Table 4. Functional properties of Watermelon, and Pumpkin seed flour.

Materials	WAC (Ml/g)	OAC (Ml/g)	FC (%)	BD (g/ml)
Watermelon	3.20 ± 0.19 [b]	3.93 ± 0.19 [b]	9.67 ± 0.31[b]	0.77 ± 0.17 [b]
Pumpkin	5.60 ± 0.03 [a]	3.50 ± 0.19 [b]	19.0 ± 0.57 [a]	1.5 ± 0.05 [a]

Means ± standard deviation of three replicates. Means in the same raw with different letters are significantly different (P < 0.05). LSD = Least significant.

Table.5. Least gelation concentration (%) of Watermelon, and Pumpkin seed flour.

sample	2%	4%	6%	8%	10%
Watermelon	-	±	+	+	++
Pumpkin	+	±	++	++	+++

- No gel ++ Strong gel
+ Weak gel +++ Very strong gel
± Very weak gel

[30]. **Hayat** [30].**;Shayo et al** [31]. **(1992),** and **Al khalifa,** [32]. and it was found in range of 1.85-5.2%. **Oil conten**t of watermelon was found to be 29.00% slightly similar to the range of 25.8 to 28.7% reported by (**Mustafa *et al.*** [27].**)**. The noticeable variation in oil contents may be attributed to varietals differences, source of seed and climatic and growing condition. **Fiber** content of watermelon was found to be 2.6%, this result agreed with range (2.4% and 6.14%). found **by Ogunuga** and **Fetuga,** [28] **and Al-Khalifa et al.,** [32]. The **protein content** was found to be 17.03 % which was lower than that reported (18.96%) by **Mustafa, *et al*.,** [27].**,;** and higher than the range between (13.5%) and (16.4%) **Asil,.,** [33]. and **Rakhimove, *et al*.,** [34]. **Carbohydrate** was found to be 38.6% .the value of carbohydrate obtained in this result agreed with range of carbohydrate in water melon seeds from different places between 23.4% and 45.1% **Alkhalifa** [32]. The value of **Carbohydrate** found in Watermelon was found to be 38.6% agreed with range obtained of carbohydrate in watermelon seeds obtained from different places 23.4% and 45.1% **Alkhalifa** [32].**)**

The moisture content of pumpkin seeds (5.85%) was approximately similar to that reported by El-Gharabawi [38] and Kamel [37] (6.03% and5.1%) respectively.

The ash content was found to be 6.00%. lower than that reported by Gharabawi [38] reported (8.63%), and higher than that (4.7% and 5.1%) reported by Cirrilli [38] (1971) and Kamel [37], respectively. This difference may be due to variation between varieties. **Oil** and **fiber content** of pumpkin flour (35.55% and 24.9%) was found to be higher than that (0.8%) reported by Giami *et al*. [38]**.,** and Kamel [37], (3.74%) respectively. This difference possibly due to preparation conditions of flour.

The protein content was found to be 17.09% which is lower than that of defatted pumpkin seed flour (45.9%) reported by Giami *et al*. [38]**.,** (34% and 25.5%) reported by Kamel [37], and Kim *et al*. [40], respectively, and this possibly attributed to defatting process. This agreed with sharama *et al*. [42], who reported defatting of pumpkin seed flour increased the content of the protein over 70% on dry weight. watermelon and pumpkin seeds contained appreciable amount of crude protein content (17.09%and 17.1%respectively) making them a good source of supplementary protein for man and livestock feeds. **Carbohydrate** was found to be 10.61% and this value slightly lower than that (14.89%) obtained of by El-Gharabawi [38]**.**

Chemical characteristics of oil content

Chemical characteristics of oil content are represent in (Table 2). Acid value showed no significant differences between pumpkin and watermelon seed flours ($P < 0.05$). However, pumpkin seed flour showed higher value with respect to free fatty acid, compare to watermelon. The data obtained in this results were comparable to the result obtained by **Azeem *et al.*,** [43]**.**

Minerals content

The minerals content of pumpkin and watermelon seeds is presented in (Table 3). watermelon showed the highest content of Ca,and Mg, Compared to pumpkin. On the other hand, pumpkin showed the highest content of K (14.0 mg/100g), The mineral contents vary according to the plant species and varieties. The result presented in the current investigation are lower than the previous study by Mallek-Ayadi, *et al.,* **44** (2018), who reported that sweet melon peels have adequate supply of minerals, potassium (1148.75 ± 1.53 mg/100g) magnesium (1062.25 ± 0.72 mg/100g) calcium (506.13 ± 1.52 mg/100g) and sodium (336.5 ± 0.72 mg/100g).

Functional properties

Functional properties are important in determining quality as they give information on how food ingredients will behave in a food system.

Water holding capacity

I**s** the ability to retain water against gravity and includes bound water, hydrodynamic water, capillary water and physically entrapped water. The WAC is an important functional property of flours due to swelling, and it's affect the characteristics of body thickness and viscosity **Sideeg *et al***., [44]**.** The results of water and oil absorption capacities of watermelon and pumpkin seed flour (Table 2). pumpkin showed higher water absorption capacity (5.60 Ml/g) than that reported for watermelon (3.20 Ml/g). The result of WAC of watermelon agreed with the results obtained by (**Akusu *et al*.,** [45] who reported that the (WAC) value of watermelon was 3.2 ml/g. The low water absorption capacity of watermelon flour may be attributes to its low protein contents. Rhee *et al*. [46] , reported that the water absorption capacity (WAC) of sunflower and soy products increased with increasing protein content. However, Fleming *et al*. [47]. Mentioned that WAC is attributed to the protein content of the food. Variation in water absorption capacity might be due to the different proportion of non polar side chains of the amino acids on the surface of the protein molecules. The results may give an advantage to Pumpkin seed flour in some foods, especially comminuted meal with good water absorption capacity.

Watermelon gave higher values of oil absorption capacity (3.93Ml/g) than pumpkin seed flour (3.50 Ml/g). Variation in oil absorption capacity might be due to the different proportion of non polar side chains of the amino acids on the surface of the protein molecules. Several authors have reported the oil absorption capacity to non polar side chains of the protein as well as to different conformational features of the protein Taira, 1974 [48].

Bulk density

The bulk density is defined as the mass of many particles of material divided by the total volume occupied. (particle volume and internal pore volume. Bulk density depends on the particle size and initial moisture content of the flours. The bulk density (BD) of pumpkin was found to be 1.5 g/ml. The value obtained was higher than that reported for watermelon 0.77 g/ml and the values for pumpkin seed flour 0.18-0.38 g/ml stated by Hassan [49] and Fagbemi *et al*. [50] respectively. Variations in results are probably due to the variation in particle size, preparation methods and cultivar. Watermelon bulk density was found to be 0.77(g/ml) agreed with that reported 0.77 g/ml (Hassan, [49]).). high bulk density of flour suggests their suitability for use in food preparation. Low bulk density would be an advantage in formulation of complementary foods.(Akapata, and Akubor, [51]

Foaming capacity (FC)

Foam capacity is an important charteristic feature of most proteins. The foam property of a product was found to be important and FS is the most important factor. Foaming capacity of . Pumpkin flour was found to be (19.00 %) which was higher than that reported for watermelon (9.67 %), and higher than the values (18.2%) stated by El-Adawy and Taha [52] and Hassan [49] for pumpkin, however, Foaming capacity (FC) of watermelon value in this result was lower (9.67 %), than that reported (20.5-20%) by Fagbemi *et al*. [50]. The result of Foam capacity of watermelon seed flour agreed with the result obtained by Oyeleke *et al*., [53]. They reported (9.67%).this variation may be due to the differences in varieties.

Foam stability (FS) Figure 3 shows the foam stability of watermelon and pumpkin seed. Foam

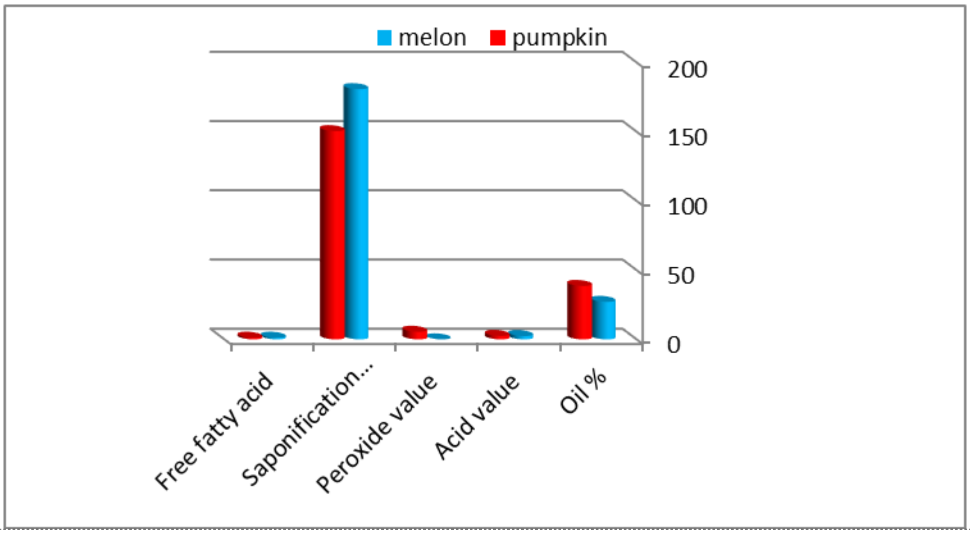

Figure 2. Chemical characteristics of oil content of watermelon, and pumpkin seed flour

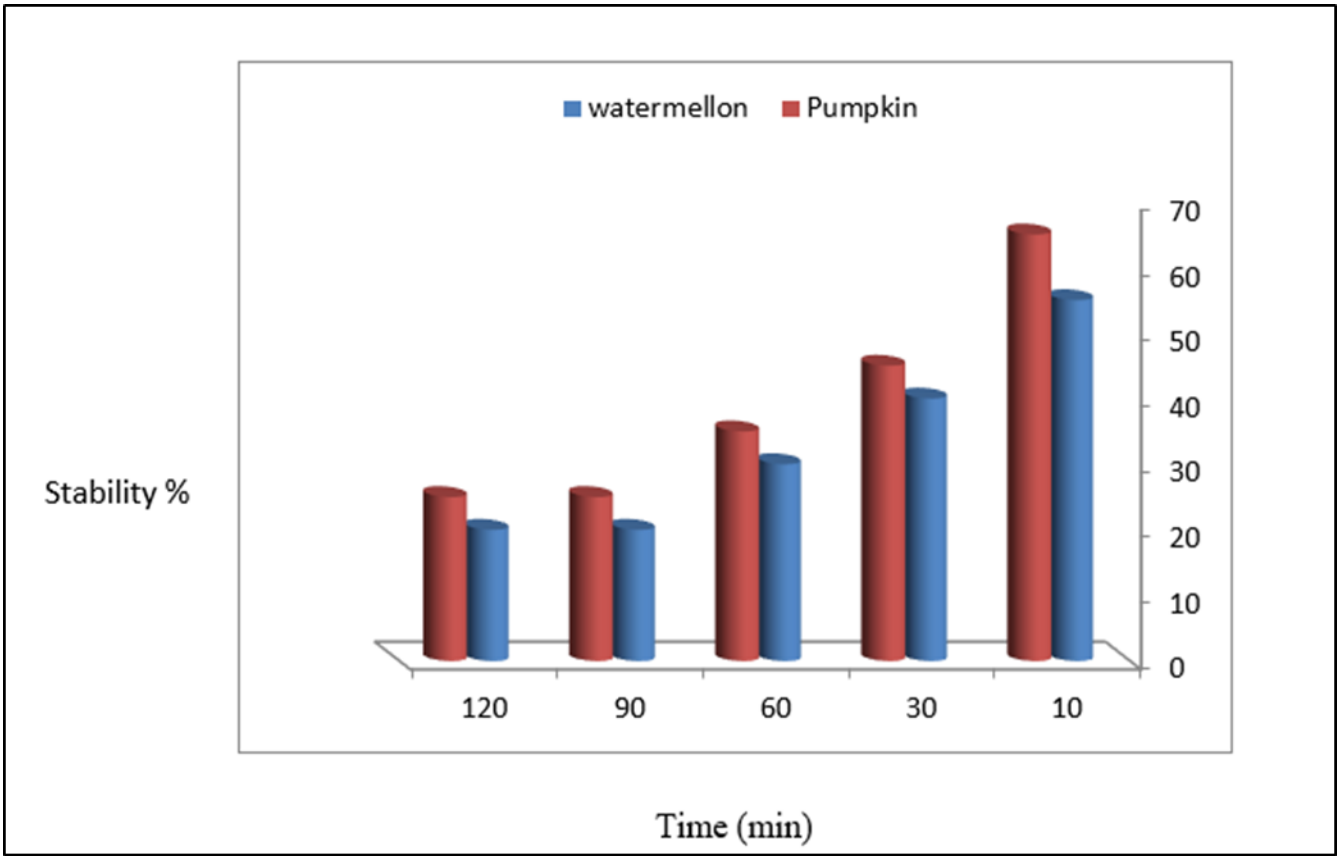

Figure 3. Foam stability of Watermelon and pumpkin seed flour

Stability of pumpkin seed flour was found to be 65.05% after 10 min and as the time increased to 120 min it was reduced to 25.43%. watermelon seed flour showed similar result as reported by Hassan [49]. Pumpkin seed flour showed good dispersion at pH 7 then at pH 10. Johnson [53]. reported that good dispersion of vegetable proteins in water at a neutral pH or at alkaline pH reasonably due to solubility of protein; isolate soy protein and casein at neutral pH (6.5-7) have good water dispersion characteristics. The high stability of foams in alkaline pH may have been due to the formation of stable molecular layers in the air-water interface, which impact texture, stability, elasticity to the foams.

Gel formation

The ability of proteins to form gels and provide a structural matrix for holding water, flavors, sugar, and food ingredient is useful in food applications and in new product development. pumpkin seeds form strong gel at 8% and very strong one at 10%. Watermelon form strong gel at 10%. Very weak gel formed at 2%. Similar results were obtained by Hassan [49]) This difference might be due to starch or starch-protein interaction

Conclusion

The result of this study showed that watermelon and pumpkin seeds were rich in protein and its oil acceptable according to its chemical properties. The seed could be used in infant food formulation and the seed- oil could also be a useful source of oil for both domestic and industrial uses instead of depending solely on palm oil and peanut oil that are scarce and costly.

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