Preparation of a protein isolate from flaxseed meal and a study of its chemical and functional properties

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Abstract:
The present study aimed to isolate protein from flaxseed meal after oil extraction using alkaline extraction at a pH = 3.5, and to study the chemical composition and functional properties of raw flaxseed powder, degummed and defatted powder, and flaxseed meal protein isolate. The results showed a significant increase in the protein content, reaching 79.25% in the protein isolate, compared to 20.68% in the raw seeds. The values of essential and non-essential amino acids and mineral elements also significantly increased in the protein isolate. The results showed that the flax protein isolate had a significantly excelled in water absorption capacity of (9.6) ml water/g protein compared to raw flax and degummed and defatted powder, which amounted to (5.895, 3.155) ml water/g protein, respectively. The protein isolate showed the highest fat absorption capacity of (5.65) ml oil/g protein compared to raw flax and degummed and defatted powder, which amounted to (1.93, 1.275) g oil/g protein, respectively. The highest emulsifying activity of the protein isolate was (89.53)%, followed by the degummed and defatted powder and raw flax (52.32, 65.21)%, while the emulsion stability was (72.12, 37.11, 24.50)%, respectively. The foam capacity and stability at different pH values (7, 6, 5, 4) showed that the lowest foam capacity was at pH (4). They reached (29.22, 23.37, and 20.32)%, respectively, while their highest value was at pH (7), reaching (67.33, 41.35, and 36.50)%, respectively. The foam stability of all samples decreased with increasing time.
Keywords: Water holding capacity, Emulsification, Foam stability , Degummed powder

Introduction

Our contemporary world faces significant challenges in restoring nutritional balance for various segments of society. According to statistics, approximately 800 million people suffer from hunger, approximately two billion people suffer from a deficiency in one or two micronutrients, and at the same time, more than half a billion people suffer from obesity. To address these problems, researchers have conducted research and studies on the nutritional system, whose mission is to address malnutrition and combat hunger[14]. Therefore, the search for alternative sources of animal protein with plant protein has increased in importance nowadays due to increasing consumer concern about the high cost of animal protein and to fill the shortage in animal protein availability. Therefore, plant proteins have become a good source of dietary protein, especially in developing countries. Proteins are the basic structural and functional component of many foods, such as meat, egg whites, cheese, legumes, and many grains. Protein plays an important functional role in maintaining life. It is the structural component of muscles and many body tissues and is involved in the formation of hormones, hemoglobin, and enzymes. Therefore, plant

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proteins have attracted significant interest as a low-cost source of protein, especially for vegetarians, athletes, and bodybuilders. Flax seeds are an annual winter oilseed crop belonging to the Linaceae family and the scientific name is Linum usitatissmum [15] It is one of the oldest plants known to man, as the history of the flax plant dates back to 6000 years BC, as it was used in Mesopotamia for its importance and various benefits in human food, biopharmaceuticals, fibers, and fodder Flax seeds are rich in unsaturated fatty acids, especially the fatty acid (ALA) Linolenic Acid [4,[

Flax seeds contain oil ranging between 45-35%, of which saturated fatty acids are palmitic and stearic (5.22, 16.20)%, respectively, while unsaturated fatty acids are oleic (16.20)%, alpha-linolenic acid (50.88)%, and linoleic (15.18)% [13]. They contain fiber (28%) and antioxidants (75.30%) [25]..Approximately 50% of the secondary plant waste generated during industrial production is wasted, negatively impacting the environment and costing a lot of money. Plant waste is a rich source of nutrients that support human health and prevent disease [28..[

Despite the great value of flaxseeds, they are not fully utilized and are sometimes discarded as waste or used as livestock feed in many developing countries. Therefore, these wastes must be utilized. In recent years, the industry of extracting oils from aromatic and medicinal plants has spread in Iraq and most countries around the world. This industry produces large amounts of waste (flaxseed meal) that are good sources of crude protein, energy, and some nutritional compounds on the one hand, and are inexpensive on the other hand [21]. Given the functional and nutritional properties of flaxseed, this study aimed to prepare a protein isolate from flaxseed waste and study its functional properties to benefit from it as a nutritional component in fortifying foods to increase their protein content.

-2Materials and Methods:

2-1Sample Preparation:

Flaxseed Meal: Flaxseed meal was taken from the press after oil extraction and stored in polyethylene bags at -8°C until use. The seeds from which the meal was taken were identified at the Seed Testing and Certification Department of the Department of Life Sciences, College of Science, University of Baghdad. It was confirmed that the seeds were of the Linum variety, which belongs to the Linaceae family.

2-2Extraction of Gum from Flaxseeds:

Gum was extracted from flaxseed meal according to [16]. 25 grams of flaxseed meal powder was mixed with 1000 ml of water and left for three hours on a magnetic stirrer at 40°C. The sample was filtered through a cloth to extract the gums. The flaxseeds were then placed in plates to dry at 40°C, then ground and refrigerated until use. 3-2 Extraction of Fat from Flaxseed Powder

Fat was extracted from degummed flaxseed powder according to the method of [17]. The ground degummed flaxseed powder was treated with hexane at a ratio of 5:1 (w/v) under continuous stirring using a magnetic stirrer for three hours. The filtrate was then separated by vacuum filtration using a Buechner funnel and filter paper (1). Whatman No. 1. The degummed powder was left to air dry at room temperature for 24 hours to remove the solvent. The powder was ground and sieved using a 60-mesh sieve and stored in a freezer at -18°C until use.

2-4Preparation of Protein Isolate from Flaxseed

The protein isolate was prepared from degummed and degummed flaxseed powder

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according to the method of [11] with some modifications. The degummed and degummed flaxseed powder was mixed with water at a ratio of 1:1. 15:1 (weight/volume(
i.e., for every 1 gram of degummed and defatted flaxseed powder, 15 ml of distilled water is added. The pH is adjusted to 8.5 using 1 M sodium hydroxide and mixed for 1 hour using a magnetic stirrer. The filtrate is then centrifuged at 4,500 rpm for 30 minutes, after which the filtrate is separated from the precipitate. The filtrate is then removed and the pH is lowered to 3.8 using 1 M hydrochloric acid. The filtrate is then centrifuged at 4,500 rpm for 20 minutes, and the precipitate is separated from the filtrate. The precipitate is then washed several times with distilled water and returned to the centrifuge to remove the acid. The precipitate is then dried at 40°C and frozen until ready to use.

2-5Chemical Composition Estimation: Proximate Analysis

The chemical compositions of raw flaxseed, degummed and defatted powder, and the protein isolate of flaxseed were estimated. Flax Moisture, ash, protein, fat, fiber and carbohydrates were determined according to the method mentioned in [5.[

2-6Analysis of mineral elements:

The mineral elements were estimated using a flame photometer and an atomic absorption spectrometer, following the method described in [9.[

2-7Amino acid analysis

Amino acids were extracted according to the method proposed by [8]. The test was conducted in the laboratories of the Ministry of Science and Technology / Department of Environment and Water using a Korean-made amino acid analyzer. The carrier phase consisted of (methanol: acetonitrile: 5% formic acid in ratios of (20, 60, 20) at a flow rate of (11 ml/min.(
A separation column (ZORBAX ECLIPSE-AAA; 3.5 um; Lxi.d = 150 × 4.6 mm) was used.

2-8Estimation of functional properties

2-8-1Water absorption capacity:

The water absorption capacity of raw flaxseed powder, degummed and defatted flaxseed powder, and protein isolate was estimated using the method described by [20]. 1 g of the sample was placed in a 15 ml test tube, previously weighed, and 10 ml of distilled water was added gradually, stirring with a Vortex to ensure that the sample was saturated with water. It was left for 30 minutes at room temperature. A centrifugation was performed at 2000 x g for 20 minutes, and the filtrate was removed. The tube with the sample was weighed, and the amount of bound water was measured as follows:

WAC=(w2-w1)/W0

W0 = dry sample weight

W1 = tube weight + dry sample before adding water

W2 = tube weight + precipitate weight after adding water

2.8.2Fat Absorption Capacity:

The fat absorption capacity of raw, degummed, and defatted flaxseed powder samples and protein isolate was estimated according to [20] with some modifications. 1 g of sample was weighed into a pre-weighed 15 ml centrifuge tube and mixed with 10 ml of sunflower oil using a Vortex mixer to ensure the sample was fully saturated with fat. The mixture was left at room temperature for 30 minutes, then centrifuged at 4000 rpm for 30 minutes. The filtrate was carefully removed, the tube with the sample was weighed, and the fat absorption capacity was measured in grams per gram of sample.

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FAC=(F2-F1)/(F0(

F0 = dry sample weight

F1 = tube weight + dry sample weight before adding oil

F2 = tube weight + precipitate weight after adding oil

2-8-3Determination of Emulsifying Properties:

The emulsifying properties of raw flaxseed powder, degummed and defatted powder, and protein isolate were determined according to [13].. This was achieved by mixing 0.7 g of the sample with 50 ml of distilled water and 50 ml of sunflower oil in an electric mixer for 5 minutes. The pH was adjusted to 7 using 0.5 N NaH 2+. The emulsifying properties were determined according to the following equation:

Emulsifying Properties % = (Volume after mixing – Volume before mixing / Height before mixing) × 100

The emulsion stability was determined by heating the mixture in a water bath at 90°C for 30 minutes, then cooling it directly with tap water. The stability was then calculated according to the following equation:

Stability Emulsification % = (Volume after heating / Volume before heating) × 100

2-8-4Estimation of Foam Capacity and Stability:

The foam capacity and stability were estimated for all samples under study according [3]. 1 g of each sample was mixed with 100 ml of distilled water at pHs of 4, 5, 6, and 7 using a 1-molar solution of sodium hydroxide (NaOH) or hydrochloric acid (HCl), as needed, in a laboratory mixer for 5 minutes. The foam volume was then monitored at different time intervals, including 120, 90, 60, 30, and 0 minutes. The foam capacity and stability were then calculated using the following equation:

Foam Capacity and Stability % = (Volume after beating (ml) – Volume before beating (ml) / Volume of the solution before beating) × 100

2-9Statistical Analysis:

The statistical program was used. [26]Statistical Analysis System

In data analysis to study the effect of the various studied treatments, a completely randomized design (CRD) was used. Significant differences between means were compared using the least significant difference (LSD) test.

.3Results and Discussion

3-1Estimation of Chemical Constituents:

Table (1) shows the percentage of chemical constituents of raw flaxseed, degummed and defatted powder, and protein isolate, represented by (moisture, ash, protein, fat, fiber, and carbohydrates). The results of our current study showed that the moisture content of raw flaxseed reached 6.01. These results were consistent with [23] study, where the moisture content reached 6.5%. It was higher than [27] where the moisture content reached 5.07%, and lower than [10] where the moisture content reached 9.27%. The results in the same table also indicate a decrease in the moisture content. The moisture content of the degummed and defatted powder and the protein isolate was significant, reaching (2.65, 5.66)%, respectively. [24] indicated that the moisture content of the degummed and defatted powder and protein isolate of lupins reached (1.74, 4.56)%, respectively, of lupins reached (1.74, 4.56)%, respectively,

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Table 1 shows the chemical composition of raw flax seeds, degummed and defatted powder, and isolated protein.

Carbohydrates	Fiber	Fat	Protein	Ash	Moisture	Model
14.39	15.65	40.25	20.68	3.02	6.01	Raw Flaxseed Powder
37.32	14.11	2.56	36.8	3.55	5.66	Degummed and Defatted Powder
10.84	3.65	0.81	79.25	2.80	2.65	Protein Isolate
7.844 *	3.176 *	2.140 *	11.571 *	0.602 *	2.19 *	LSD Value
) *P≤0.05.(						

The results of Table (1) also indicated that the ash percentage in raw flax seeds, defatted and degummed powder, and protein isolate reached 3.00, 2.80, and 3.55%, respectively. This was consistent with the study of [27] where the ash percentage of raw flax reached 3.80%. It was also consistent with [18] , where they found a significant decrease in the ash percentage in okra protein isolate, which reached 2.67% compared to defatted okra powder and okra protein concentrate, which reached 9.94 and 8.45%, respectively. The protein percentage in raw flax seeds reached 20.68%. These results are consistent with [22,23] The protein percentage reached 22.3% and 25.66%, respectively. [10] explained that the protein percentage in flax seeds was 38.41%, while [30] reported that the protein percentage in soybean meal and sesame meal reached (53.5, 48)%, respectively. The difference in protein percentages is due to differences in the varieties and agricultural practices used and differences in the production environment The results also indicate a significant increase in the protein percentage in the flax protein isolate, reaching (79.25)%. The results also indicate a significant decrease in the percentage of fat in defatted and defatted flaxseed powder and protein isolate, with the percentage of fat reaching 0.81% and 2.56%, respectively. [2] indicated that the percentage of fat in the protein isolate of mung beans was 0.24%. The results in the same table showed that the percentage of fiber in raw flax seeds reached (15.65%), and this percentage is less than what was mentioned by: [14] as the percentage of fiber in raw flax seeds reached (28%), and higher than what was mentioned by [22], as the percentage of fiber in flax seeds was (8.833%). The results showed a significant decrease in the percentage of fiber in the protein isolate, as the percentage reached (3.65%). [19] indicated that the percentage of fiber in the protein isolate of sunflower seed cake was (5.33%), and [1] stated that the percentage of fiber in the protein isolate of peas and soybeans reached (0.2, 4.1)%, respectively. As for carbohydrates, the percentage of carbohydrates in raw flax seeds was (14.39%), [18] reported that the percentage of carbohydrates in the okra protein isolate reached (3.26%), while ([10] reported that the percentage of carbohydrates in sesame seed cake reached (32.31%.(

3-2Estimation of Mineral Elements:

Table (2) shows the mineral content of flax seeds, degummed and defatted powder, and flax protein isolate, which included: calcium, phosphorus, iron, magnesium, and zinc. The

results indicate a significant decrease. Statistically, at the probability level ($P < 0.05$), the content of mineral elements in the degummed and fat-removed powder and protein isolate compared to raw flax seeds reached (43.1,741.5,5.78,472.42,355.2), (30.2,440.6,3.36,282.11,266.9.((257.4 ,345.16 ,4.15 ,512.6 ,28.9)mg/100, respectively.

Table 2 shows the mineral content of raw flaxseed, degummed and defatted powder, and protein isolate.

LSD value	Protein isolate mg/100g	Degummed and defatted powder mg/100g	Raw flaxseed powder mg/100g	Minerals
42.57 *	266.9	257.4	355.2	Calcium
65.96 *	282.11	345.16	472.42	Phosphorus
1.59 *	3.36	4.15	5.78	Iron
75.48 *	440.6	512.6	741.5	Magnesium
6.92 *	30.2	28.9	43.1	Zinc
) *P≤0.05.(				

These results agreed with [24] who noted a significant decrease in mineral elements (calcium, phosphorus, iron, magnesium, zinc) in the protein isolate of lupin compared to the raw seeds, as they were in the raw lupin seeds (38,583,190,2800,956) mg/kg, respectively. As for the protein isolate of lupin, the mineral elements reached (29,148,42,685,743 mg/kg, respectively.(

3-3Amino Acid Estimation:

Table (3) shows the amino acid contents in both raw flaxseed powder and protein isolate. The table indicates the presence of (16) amino acids, including (7) essential amino acids (histidine, lysine, threonine, lysine, valine, methionine, phenylalanine) and non-essential amino acids (aspartic acid, aspartate, serine, alanine, tyrosine, arginine, cysteine, proline, glycine.(

Table No. 3 shows the amino acid content of raw flaxseed and protein isolate.

LSD value	Isolated protein mg/100g	Raw flax powder mg/100g	Amino Acids
3.59 *	20.11	11.25	Aspartic Acid
4.08 *	23.65	13.65	Asparaginin
4.51 *	25.98	11.24	Histidine
5.02 *	25.49	12.80	Lysine
5.48 *	33.65	14.55	Serine
7.31 *	34.91	13.65	Threonine

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5.37 *	24.58	11.48	Leucine
4.98 *	33.65	10.80	Alanine
3.29 *	24.15	8.98	Valine
4.87 *	33.69	10.25	Thyrosine
5.18 *	40.58	12.44	Arginine
5.67 *	36.59	17.80	Cysteine
4.81 *	35.98	19.08	Methionine
4.37 *	41.57	15.88	Proline
3.97 *	32.69	12.65	Phenylalanine
3.02 *	24	11.80	Glycine
) *P≤0.05.(			

Methionine, cysteine, and proline recorded the highest levels in raw flaxseed, reaching values of 15.88, 17.80, and 19.08 mg/100 g. In the protein isolate, the amino acids proline, arginine, and cysteine had the highest levels, reaching values of 36.59, 40.58, and 41.57 mg/100 g. The results of the statistical analysis indicated a significant increase in the amino acid levels in the protein isolate at the level of (P≤0.05). [24] indicated that glutamic acid recorded the highest levels in each of the defatted lupine seed powder, lupine protein concentrate, and lupine protein isolate, reaching (20.6, 21.3, and 22.2)%, respectively, followed by the amino acids aspartic, arginine, and threonine. 4-3 Functional Properties of Raw Flaxseed Powder, Degummed and Defatted Powder, and Protein Isolate

3-4-1Water Absorption Capacity:

Table (4) and Figure (1) show the water and fat absorption capacity, emulsifier activity, and stability of raw flaxseed powder, degummed and defatted powder, and protein isolate. Table (4) and Figure (1) show significant differences in water absorption capacity between raw flax, degummed and defatted powder, and protein isolate. The highest water absorption capacity was for the flax protein isolate, reaching (9.6) ml/g protein, while the lowest water absorption capacity was for the raw flaxseed powder, reaching (3.155) ml/g protein. The results obtained in this study were higher than those found by Tolabi (2005), where the water absorption capacity of the flax protein isolate was (6.8) ml water/g protein, and lower than those found by[6, 29] found that the water absorption capacity of flaxseed protein isolate reached 5 and 11.4 ml water/g protein, respectively

Table 4 shows the water and fat absorption capacity, emulsifying activity, and stability of raw flaxseed powder, degummed and defatted powder, and the protein isolate.

LSD Value	Protein Isolated	Degummed and Defatted Powder Protein Isolated LSD Value	Raw Flax	Functional Property
2.018 *	9.6	5.895	3.155	Water Absorption Capacity (ml water/g protein)
1.167 *	5.65	1.93	1.275	Fat Absorption Capacity (ml water/g fat)
7.943 *	89.53	65.21	52.32	Emulsification %
6.580 *	72.12	37.11	24.50	Emulsification Stability %
*(P≤0.05).				

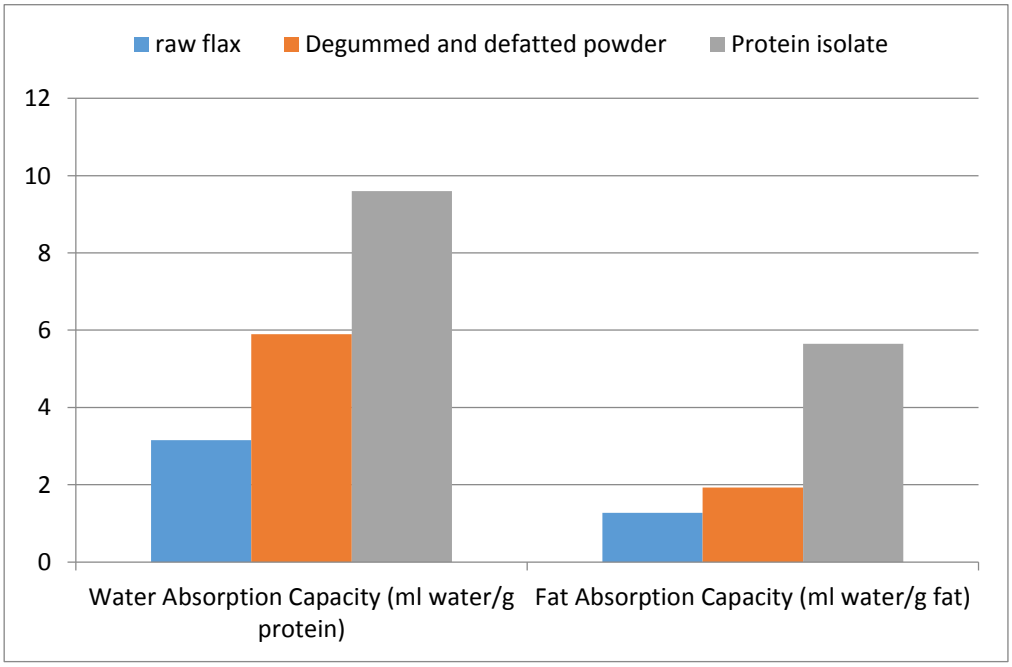

Figure 1 Water and Fat Absorption Capacity of Raw Flaxseed, Degummed and Fat-Free Powder, and Flaxseed Protein Isolate

3-4-2Fat Absorption Capacity:

Table (4) and Figure (1) show the fat absorption capacity of raw flaxseed powder, degummed and fat-free powder, and protein isolate, which reached (5.65, 1.93, and 1.275) ml fat/gm fat, respectively. The highest fat absorption capacity was achieved in the flaxseed protein isolate. The results of the statistical analysis indicated a significant difference in fat absorption capacity between

the raw powder and the protein isolate, while there was no significant difference for the degummed and fat-free powder, where the ratio reached (1.93) g fat/gm protein. ([10] indicated that the fat absorption capacity of raw flax reached (0.91) ml fat/protein, while [6] indicated that the flaxseed isolate was superior in fat absorption capacity, reaching (1.7) g fat/protein compared to the sunflower and safflower isolate, which reached (1.1, 1.5) ml fat/g protein, respectively. These results were consistent with the study of Dahham & Abas (2023), as they indicated the superiority of the protein isolate of mung bean seeds over the defatted powder, as the fat absorption capacity was (1.7, 0.3) ml fat/g protein, respectively. [20] explained that the protein isolate of walnuts was characterized by the highest fat absorption capacity, reaching (3.57) g fat/g protein, followed by the protein concentrate and defatted powder, which reached (3.11, 2.94) g fat/g protein. gram of protein, respectively .The superiority of the protein isolate over the defatted powder in its ability to absorb lipids is due to the increased nonpolar side chains of the protein, in addition to the presence of hydrophobic groups within the amino acid structure. These groups contribute to the formation of hydrophobic bonds with lipids, which increases the amount of bound lipids.

3-4-3-Estimation of Emulsion Capacity and Stability:

Table (4) and Figure (2) show the emulsification capacity of the raw flaxseed powder, the defatted powder, and the protein isolate, which reached (89.53, 65.21, and 52.32)%, respectively. The results indicate that the protein isolate significantly outperformed the flax protein isolate with the highest emulsification ability compared to raw flax and degummed and defatted powder. These results were consistent with the findings of Tirgar et al (2017), as the emulsification percentage of the flax protein isolate reached 87.91% and less than what was reported by [10], as the emulsification percentage of raw flax reached 74.54%. [6] reported that the emulsification percentage of the flax protein isolate reached 58.33%. Emulsifying properties vary according to molecular weight, lipophilic groups, mass, and structural stability, in addition to physicochemical properties such as pH and temperature.. Dahham & Abas (2023) showed that the protein isolate of mung bean seeds significantly outperformed the defatted mung bean powder in terms of emulsification ability, reaching (5.769, 4.1%), respectively.

The same table and figure also show the emulsion stability of raw flaxseed powder, degummed and defatted powder, and protein isolate, as the emulsion stability capacity reached (72.12, 37.11, 24.50)%, respectively, where the highest emulsion stability was observed for the protein isolate. The results of the statistical analysis indicated that there were significant differences between the samples. These results agreed with [24], as there were significant differences in the emulsion stability between raw lupin seed powder, degummed and defatted powder, and protein isolate, as the percentage reached: (43.89, 30.38, 15.76)%, respectively

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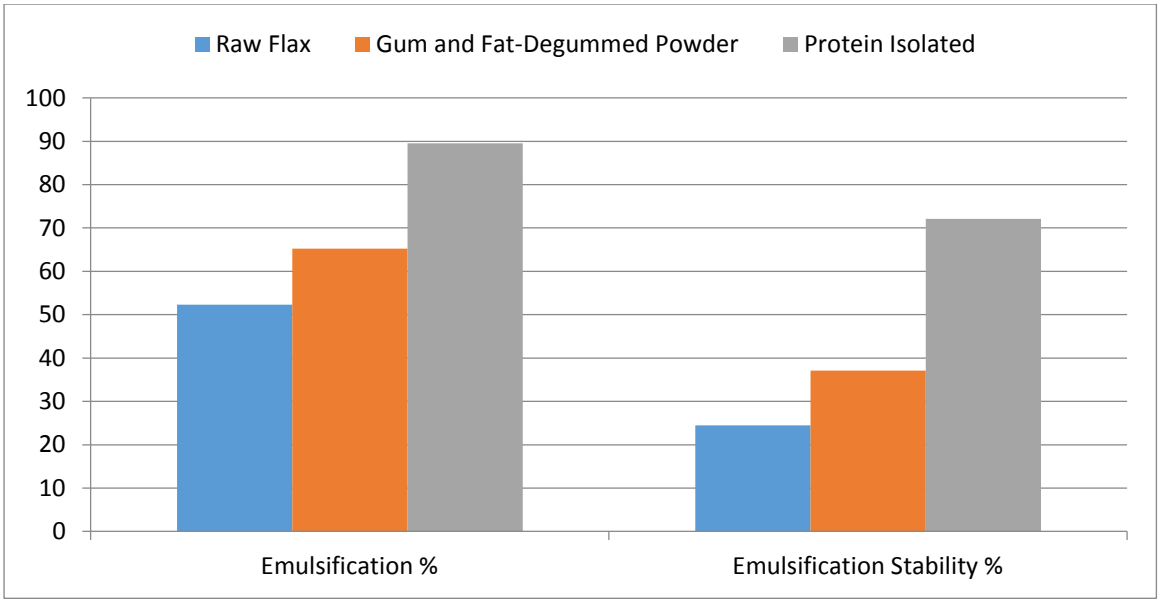

Figure 2 -Emulsification and stability of raw flaxseed powder, degummed and defatted powder, and flax protein isolate

3-4-4Foaming capacity and stability

Table (5) and Figure (3) show the foaming capacity of raw flaxseed powder, degummed and defatted powder, and protein isolate at different pH values: 7, 6, 5, and 4. The results showed that the lowest foaming capacity percentage was at pH 4, reaching (29.22, 23.37, and 20.32) for raw flaxseed powder, degummed and defatted powder, and protein isolate, respectively.

Table 5 shows the foaming capacity of raw flaxseed, degummed and defatted powder, and protein isolate.

LSD Value	Protein Isolated	Degummed and Defatted Powder	Raw Flax	
3.28 *	29.22	23.37	20.32	PH4
4.77 *	35.23	28.37	22.33	PH5
4.81 *	50.30	32.33	28.44	PH6
7.69 *	67.33	41.35	36.50	PH7
) *P≤0.05.(				

The percentage of foam capacity increased with increasing pH, reaching (50.30, 41.35, 36.50), respectively, at pH 6. The foam capacity reached its highest value at pH 7, reaching (67.33, 41.33, 36.50). The protein isolate had the highest foam capacity value, followed by the degummed and defatted powder, then the raw flaxseed powder. These results are consistent with the findings of [6] as the foaming capacity of the flax, sunflower, and safflower protein isolates increased at pH 7, reaching (44.23%), (51.75%), and

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(57.80%), respectively, compared to (22.75%), (25.50%), and (50.33%), respectively, at pH 4. The flax protein isolate was the most prominent, followed by the sunflower and safflower isolates. [2] reported that the foaming capacity of raw mung bean seed powder was higher than that of the isolated mung bean protein, but the isolated mung bean protein had a foam stability of (23.53)%, while it decreased to (10)% in the raw mung bean seed powder after half an hour. The results were consistent with the findings of [29], who noted that the foaming capacity increases significantly with increasing pH. The reason for the increase in foaming capacity with increasing pH is due to the increase in the total electrical charge of the protein, which then increases the flexibility and solubility of the protein, which leads to the diffusion of the protein at the water-air interface and the envelopment of air bubbles

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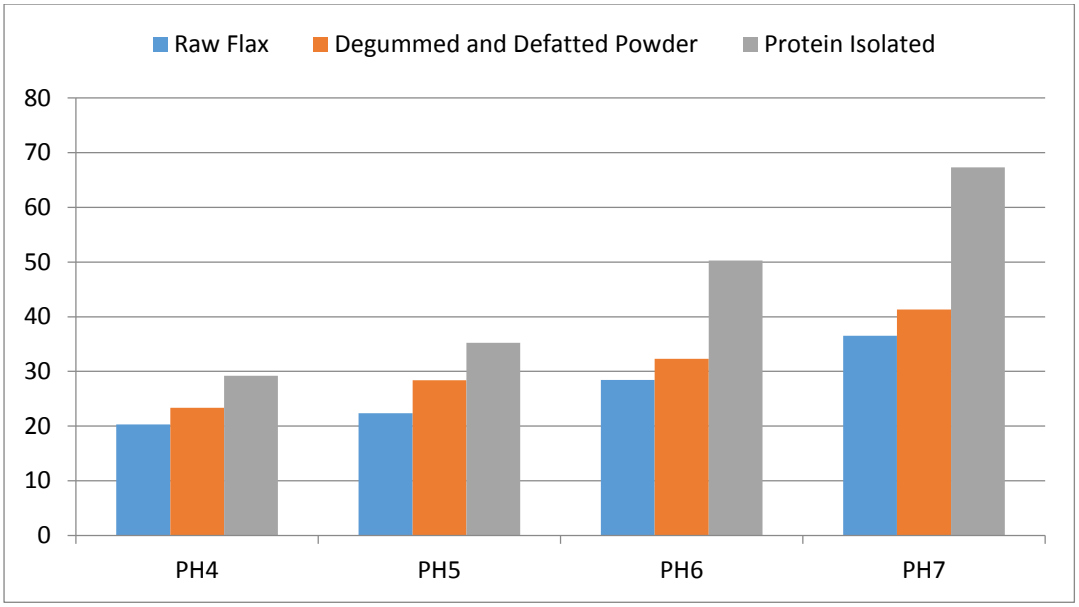

Figure 3 Effect of pH on the foaming capacity of raw flaxseed powder, degummed and defatted powder, and protein isolate.

Figure (6, 5, 4) shows the effect of pH on foam stability for raw flaxseed powder, degummed and defatted powder, and protein isolate of flaxseed meal at times ranging from 0.0 to 120 minutes. The results indicated a decrease in foam stability with increasing time from 0.0 to 120 minutes for all samples under study. The foam disappeared for all samples at time 120 minutes at pH 4, while the stability increased at pH 7, where the sample maintained foam stability, reaching (18.10, 16.8, 13.71)% for raw flaxseed powder, degummed and defatted powder, and protein isolate, respectively, at minute 120. It was noted that the protein isolate had the highest foam stability, followed by the degummed and defatted powder, then the raw flaxseed powder at all pH numbers and for all times. The results were consistent with the findings of [6] who observed a decrease in foam stability for all samples with increasing time from 0.0 to 2.0 hours, noting an increase in stability for all samples at pH 7, where the samples maintained a foam stability of (10.2, 15.00, 15.78)% for each of the flax, sunflower and

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safflower isolates at time 2.0 hours, while the stability of the same samples disappeared at pH 4 and at the same time. The foam stability increased for the flax protein isolate, followed by the sunflower protein isolate, then safflower, at all pH numbers and all times.

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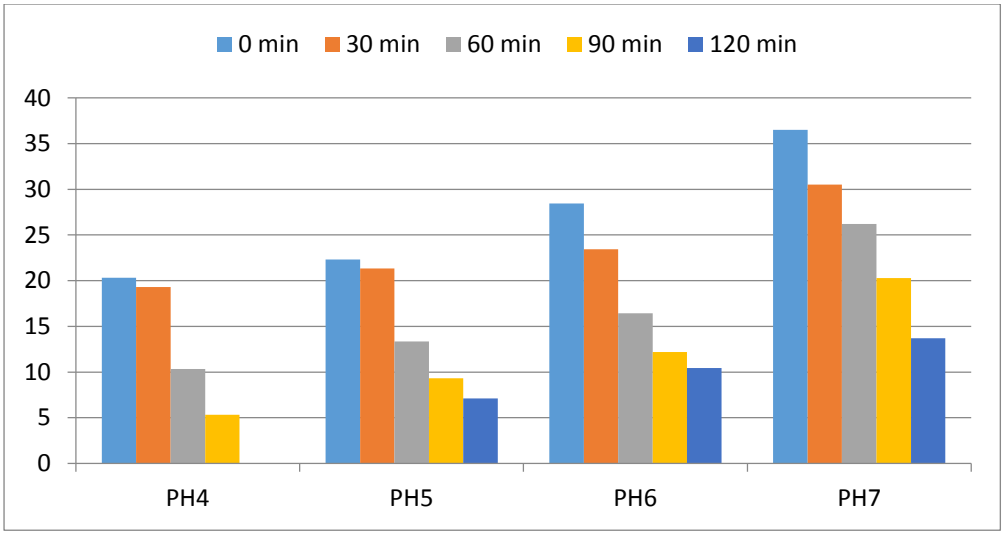

Figure 4: Effect of pH on foam stability of raw linen

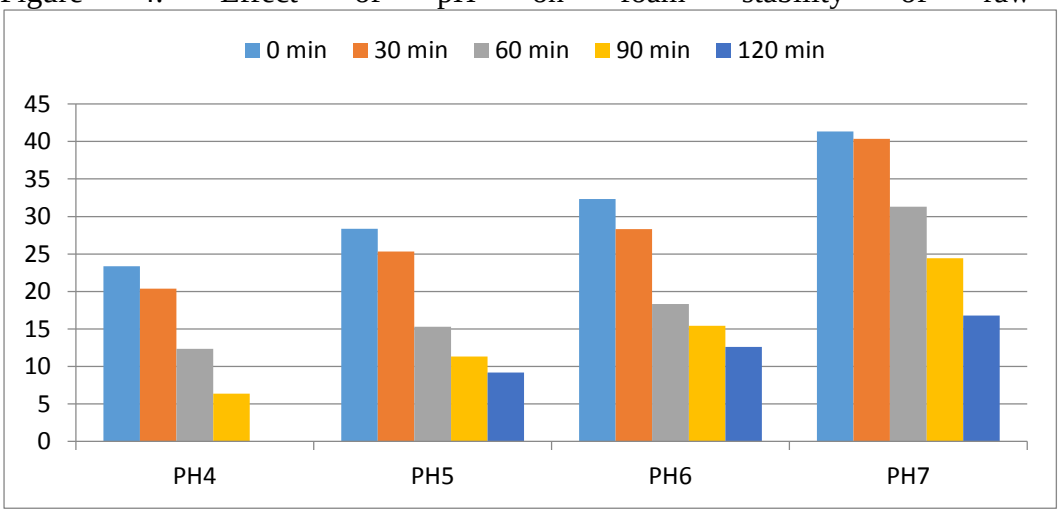

Figure 5 – Effect of pH on foam stability in gum and protein isolate powder

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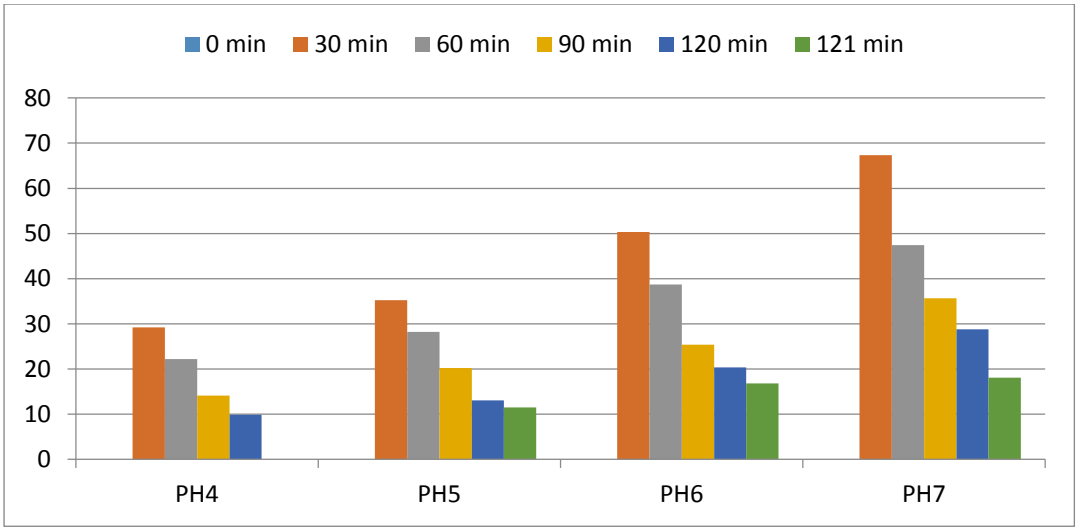

Figure 6: Effect of pH on foam stability in protein isolate

Conclusions:

The study concluded that flaxseed meal could be used to prepare a protein isolate instead of using it as animal feed or disposing of it. The protein content in the prepared isolate reached 79.25%. The flaxseed protein isolate also exhibited good functional properties, such as water and fat retention, emulsification ability, and foaming capacity. Which encourages its introduction into food manufacturing as a filler, emulsifier or stabilizer.

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