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IMPROVING THE PROPERTIES OF THE LOCALLY PRODUCED TEXTURIZED SOYBEAN

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ABSTRACT

The properties of the locally produced texturized soybean were improved through the modification of the extruder's screw (its mean effective unit) and the application of some suitable treatments. The modification was concentrated on changing the dimensions of each zone of the three screw zones (feeding, kneading, and final cooking zones). The applied treatments included two levels of fat content (7 and 1.5% fat), three levels of moisture content (15, 18, and 21%) and three types of alkaline additives (no additive, CaO 0.5% and $CaCO_3$ 1%). The tested properties of the texturizeds soybean included its components (protein, total carbohydrate, ash and moisture content), its physical properties (pH, bulk density, hardness, and water absorption capacity) beside the determination of its aggregate sizes distribution. The results showed obvious improvements of the properties for the locally produced texturized soybean since it were almost resemble to those of the imported texturized soybean.

INTRODUCTION

Soybean is one of the most important seeds in Egypt ***(A.S.A 2002)***, since it has high content of protein 38% by weight, and has favorable amino acid profile, beside its other content of oil, carbohydrate and moisture content ***(A.A.P 1998)*** .The first step of utilizing soybean protein as an improving additive in meat products, is achieved by extracting most of its oil after soybean grinding.

Soybean flour after transformation by the extruder to the structured "texturized" material will have high content of protein ***(Riaz 2002)***. The principle of extruder functioning is based on cooking utilizing high temperature under pressure for a short time.

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"Meat Products" producers refuse to use the locally manufactured texturized soybean because its particle clusters are not stable and do not maintain its structure and hardness, and do not maintain the moisture of the meat products during cooking, and all that affect the quality of meat products which suits the consumers.

The aim of this research work was to study the possibility of changing the properties of the locally manufactured texturized soybean to resemble or getting close to those of the imported texturized soybean as an additive for meat products. This improvement could be achieved by a development of the extruder and by seeking for some suitable treatments for that goal.

Some of the engineering parameters affecting the performance of the extruder are dealing with the magnitude of the created compaction on the soybean flour, since they affecting the dissipating energy by friction between the cooked material and the screw surface ***(Riaz 2002)***. This dissipated energy is converted in rising the suitable heat needed for kneading and cooking, since if affects the conversion of protein to the fibrous texture of the texturized soy bean, which could be reflected in higher hardness values of the aggregates and affects its stability ***(Gonzalo et al. 2004)***. Oil makes up about 20% of the weight in soybean seeds ***(A.A.P 1998)***, while its carbohydrate and ash make up about 35 and 7% of the weight respectively. The soybean seeds are cracked to remove the hull and rolled into full-fat flakes, ***(Egbert 2004***). The rolling process disrupts the oil cell. After extracting the oil, the defatted flakes can then be ground to produce soy flour. ***Frame, 1994; Smith & Singh, 1996*** mentioned that the extrusion cooking has become one of the most popular technologies in food processing. It is a low cost, high temperature short time (HTST) process, used worldwide for processing a number of food products**.** ***Gonzalo et al. 2004*** found that the extrusion process is the application of high temperatures (140 to 170ºC) for short periods of time (less than 90 seconds). The milled bean is sent through a cylinder with bolts that is configured in a specific manner, following which it is pushed out of a final orifice under pressure. Several parameters affect the quality of the end product. ***Kearns et al. 2003*** mentioned that the extrusion cooked texturized protein includes meat extenders in the form of chunks or small granular pieces which are wet milled or produced directly off the extruder. Extruders also are able to produce a meat analog that has a remarkable similarity in appearance; texture and mouth feel to meats. ***Lin et al. 2000*** found that the soybean protein products could be texturized either at low moisture conditions (< 35%) by single screw extruders or at high moisture conditions (> 50%) using twin screw extruders.

One of the first major applications for extruders was the production of meat analogous, ***(Dahl and Villota 1991)***. Fibrous texture can be developed during extrusion that mimics the texture of meat. Soy protein should be denatured within the extruder at a pH near the soy isoelectric point to achieve adequate texture formation. Adding sodium hydroxide (or any alkali) is detrimental to texturization.

Kearns et al. (2003) mentioned that modifying the pH to the alkaline side will increase the water absorption. Increasing the pH of vegetable protein before or during the extrusion will aid in texturization of the protein. Extreme increases in pH will increase the solubility and decrease the final quality of product, also modifying pH above 8.0 also may result in the production of harmful lysinoalanines. Lowering the pH has the opposite effect and will decrease protein solubility, making the protein more difficult to process. Undesirable sour flavors in the texturized vegetable protein products may be evident, if the pH is adjusted below 5.0.

MATERIALS AND METHODS

A single screw extruder (fig. 1) was used in this study to manufacture the locally texturized soybean. The performance of the extruder depends upon the increase of the pressure imposed by the extruder on soybean flour accompanied by the increase of temperature generated by the frication between extruder's screw surfaces and soybean flour. The temperature in the extruder during the process of the locally manufactured texturized soybean was found to be 140ºC. The extruder drive (fig. 2) consists of an electric motor 50 HP. Speed reduction and torque transfer are accomplished through the use of belts. The feeding device of the extruder is side mount and consists of an electric motor

1HP. The feed material is vibrated with shafts and is pumped by the screw of the feeding device into the extruder barrel. The extruder barrel assembly consists of a stationary barrel housing (fig. 1), a rotating screw and steamlocks, and die. The extruder barrel housing has axial groove design, to insure that the slip occurs. The extruder's screw geometry, (fig.2) can influence mixing, kneading, and heat and pressure development.

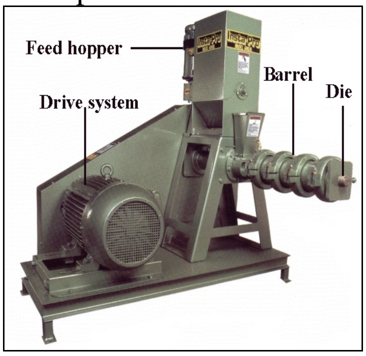


Fig. (1): The applied single screw extruder

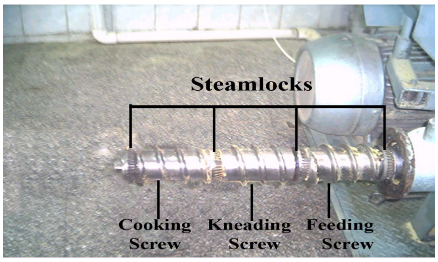


Fig. (2): A photo for the extruder's screw including the three screw sections and the four steamlocks.

The movement and transformation of material within the extruder can be categorized into three zones or sections: feeding, kneading, and final cooking zone. The design of the extruder's screw includes three pieces or parts, each has constant pitch, constant depth, and constant root diameter, and the number of flight on any part is the same in the three zones. Four steamlocks are fixed with the three screw parts to limit the beginning and the end of each zone. The dimensions of the extruder's screw are listed in table (1). A die plate serves as a restriction device at the end of the barrel which can control barrel fill, pressure, and temperature. The "die area" is the section of the extruder that occurs after the material leaves the screw. The applied die hole diameter is 1.5cm. The configuration of the extruder's die is shown in fig. (3).

Table (1):The dimensions of the screw and the barrel of the applied extruder

Items	Value
Length (cm)	37.89
Length with steamlocks (cm)	45.51
Outside Diameter (cm)	9.2
Inside Diameter (cm)	7.4
Pitch (cm)	3.5
Clearance (cm)	0.715

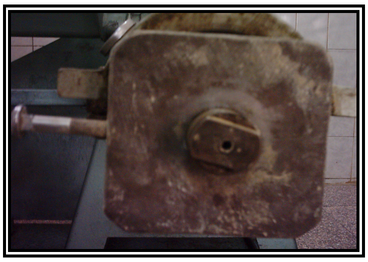


Fig. (3): The design of the extruder's die area and the die.

Development of the extruder's screw

The development was concentrated on changing the dimensions and the features of each section of the screw, to achieve three goals. The first goal is to increase the volume of the fed materials in the screw feeding zone. This action will realize the second goal which is increasing the compressing action of the second screw section to increase the effectiveness of the kneading zone and to raise its inside temperature. The third goal is to rise more the compressing action of the third screw section to increase the inside temperature of the cooking zone for additional increase of the effectiveness of the cooking zone to achieve more stable texturized soybean aggregates of higher hardness and higher water absorption capacity.

So, the feeding screw zone flight has to be very deep with long pitch. In the kneading zone, the pitch has to be decreased to accomplish more mixing in the kneading zone. In the final cooking zone, the screw has to have a short pitch. ***Riaz (2000)*** mentioned that single flight screw has to have pitch diameter ratio = 1 in the feeding zone for obtaining maximum free volume. Two flights or double flight screw with pitch diameter ratio of about 0.5 is typically used in the screw kneading zone, and either double or triple flight screws are used in the final screw cooking zone. Increasing the number of screw flights increases the screw surface to volume ratio, thus increasing the conversion of mechanical energy to heat through friction.

1- The new feeding screw design

The old design of the feeding screw zone geometry was: pitch length was 3.21cm, inside diameter was 7.1cm, and outside diameter was 9.36cm. The new design of the feeding screw zone has 3.55 cm for pitch, flight angle is 7°, inside diameter is 7.1 cm, outside diameter is 9.2 cm, and length is 12.74 cm, fig.(4) and fig (5). The inside temperature in the old design of the feeding screw zone was found to be 90ºC, but the temperature in the new design of the feeding screw zone was measured and was found to be 95ºC. The steamlock located at the beginning of the feeding screw zone has a diameter of 8.255 cm and its thickness is 1.905 cm. This steamlock separates the feeding screw zone from a similar feeding part fixed on the rotating axis of the screw, so, it separates the fed material coming from the barrel feeding device from that enters the feeding zone of the screw, while the steamlock located at the end of this zone has a diameter of 8.575 cm and a thickness of 1.905cm.

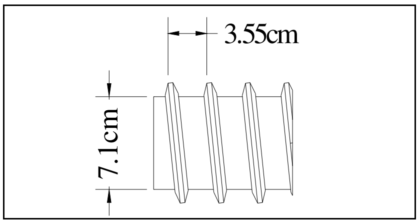


Fig.(4): The new design of feeding screw part.

Fig.(5): A photo of the new feeding screw part.

2- The new kneading screw design

The old design of the kneading screw zone geometry was: pitch length was 3.21cm, inside diameter was 7.1cm, and outside diameter was 9.36cm. The new design of kneading screw zone has 2.6 cm for pitch, flight angle is 7˚, inside diameter is 7.4 cm, outside diameter is 9.2 cm, and length is 12.74 cm, fig. (6) and fig (7). The temperature in the old design of the kneading screw zone was found to be 110ºC, but the temperature in the new design of kneading screw was measured and found to be 140ºC. The kneading screw zone is located between two steamlocks. The steamlock located before the kneading zone is 8.575 cm in diameter and its thickness is 1.905 cm, while the steamlock located after this zone is 9.207 cm in diameter and its thickness is 1.905cm.

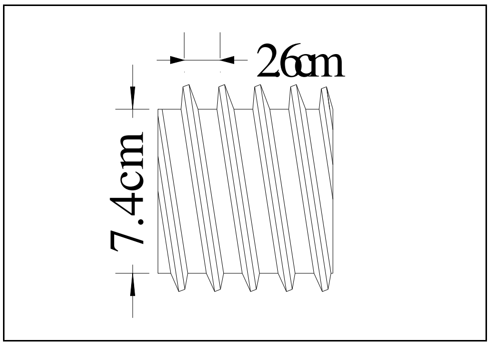


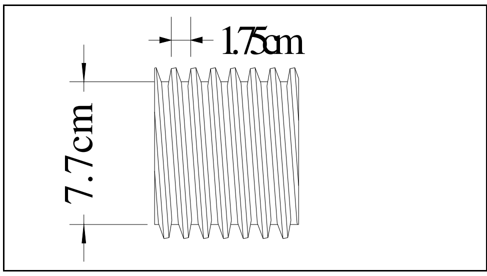
Fig.(6): The new design of the kneading screw part.

Fig.(7): A photo of the new kneading screw part.

3- The new final cooking screw design

The old design of the final cooking screw zone geometry was: pitch length was 3.21cm, inside diameter was 7.1cm, and outside diameter was

9.36cm. The new design of the final cooking screw zone has 1.75 cm for pitch, flight angle is 7°, inside diameter is 7.7 cm, outside diameter is 9.2 cm, and length is 12.74cm, fig. (8) and fig. (9). The temperature in the old design of final cooking screw was found to be 140ºC, but the temperature in the new design of the final cooking screw zone was measured and found to be 170ºC. The final cooking screw zone is located between two steamlocks. The steamlock located before this zone is 9.207 cm, while the steamlock located after this screw part is 9.525 cm in diameter and its thickness is 1.905cm.
The new desigened extruder's screw including the three screw parts and the four steamlocks is shown in fig. (10).



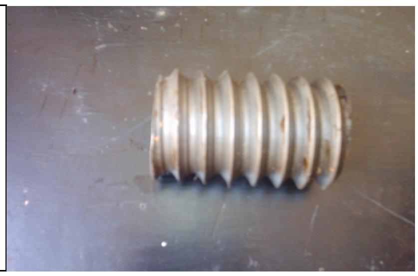


Fig. (8): The design of final screw design.

Fig. (9): The photo of final cooking screw design

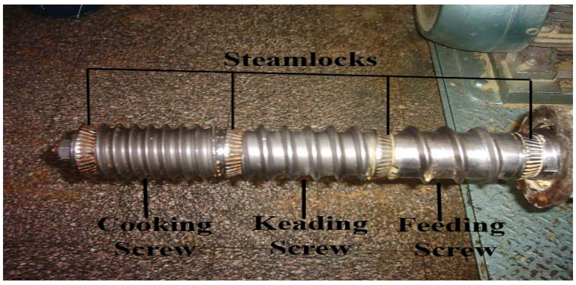


Fig. (10): A photo for the extruder's screw including the three screw zones and the four steamlocks after development

Testing the performance of the extruder's screw with the new design

The new designed extruder's screw was tested under different treatments concerning the fat content of the soybean flour, its moisture content and its alkalinity.

These treatments covered:

1- Two different values of fat content: 7% and 1.5%.

2- Three different values of moisture content: 15%, 18%, and 21%.

3- Three different modifying alkalinity: with no additive, by CaO 0.5% and by $CaCO_3$ 1%.

Symbols of the tested treatments

Treatments symbols	A	B	C	D	E	F	G	H	I
Moisture content 15%	*	*	*						
Moisture content 18%				*	*	*			
Moisture content 21%							*	*	*
With no additive	*			*			*		
By CaO 0.5% additive		*			*			*	
By $CaCO_3$ 1% additive			*			*			*

For fat content 7%, the symbols have a subscript "1"

For fat content 1.5%, the symbols have a subscript "2"

Calculation and Laboratory Measurements

1. Moisture content, crude protein, fat, total carbohydrates and ash contents were determined according to the methods described in ***A.O.A.C (1980)***.
2. The pH of soybean flour was determined using pH meter following the methods described in ***Ranganna (1977)***.
3. Water absorption capacity was measured following the method described by ***(A.A.C.C , 1995)***.
4. The bulk density was calculated from equation

$$\mathbf{D_b = 10^3 (m / V)}$$

where :

D_b = The bulk density of texturized soybean, g /l

m = The mass of texturized soybean, g

V = The volume of texturized soybean, cm^3

5. Aggregate size distribution was determined by using a set of sieves of 9.5, 3.35, 2 and 1.4 mm diameter
6. The texturized soybean hardness was determined using a digital hardness measuring instrument.
7. The rotating speed of the used screw was determined using a hand digital tachometer.
8. The temperature was determined using digital Thermometers.

RESULTS AND DISCUSSION

1- Chemical composition of texturized soybean

The chemical composition of the imported and the locally produced texturized soybean are shown in table (2).

Table (2): Chemical composition of the imported and the locally produced texturized soybean.

	Fat %	Protein %	Total Carbohydrates %	Ash %	Moisture %
Imported texturized soybean	0.5	67.5	19.5	6.6	5.9
Locally texturized soybean	7	47.1	29.8	7.3	8.8

Comparing the results of the imported and the locally produced texturized soybean, it was found that the protein of the locally texturized soybean was less than that of the imported one by 20.4%. Also, fat content, total carbohydrates, ash and moisture content of the locally produced texturized soybean were more than those of the imported one by 6.5%, 0.32%, 0.7and 2.9% respectively.

The chemical composition of the imported and the locally produced texturized soybean due to the investigated treatments before and after development of the screw are shown in fig.(11).

It was found that the values of the protein content for all the treatments at the two levels of fat (7% and 1.5%) before and after the screw development were less than that of the imported texturized soybean, but the values of the protein content for the treatments at 1.5% fat were more than those of the treatments at 7% fat.

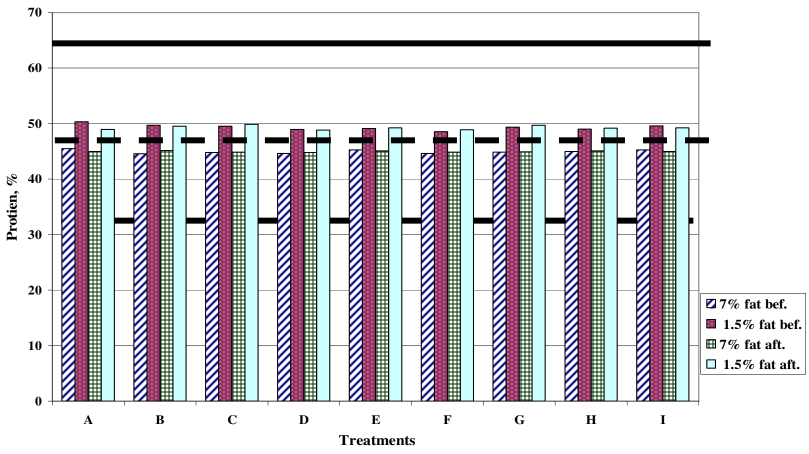
3- Physical properties of texturized soybean.

The physical properties of the imported and locally texturized soybean are shown in table (3).

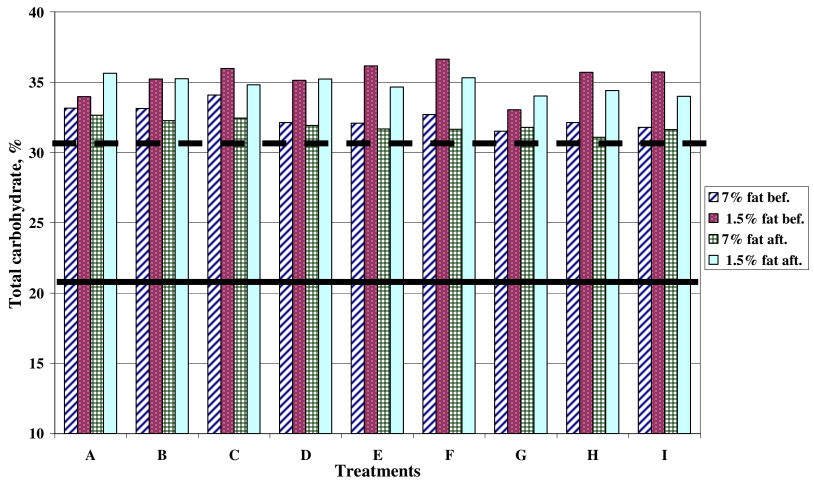
It was found that the pH and bulk density of the imported texturized soybean were less by 2% and 0.164 g/L respectively thanthose of the locally produced texturized soybean.

Also, it was found that the hardness and water absorption capacity of the imported texturized soybean were more than that of the locally produced texturized soybean by 7.1 N and 135.7% respectively.

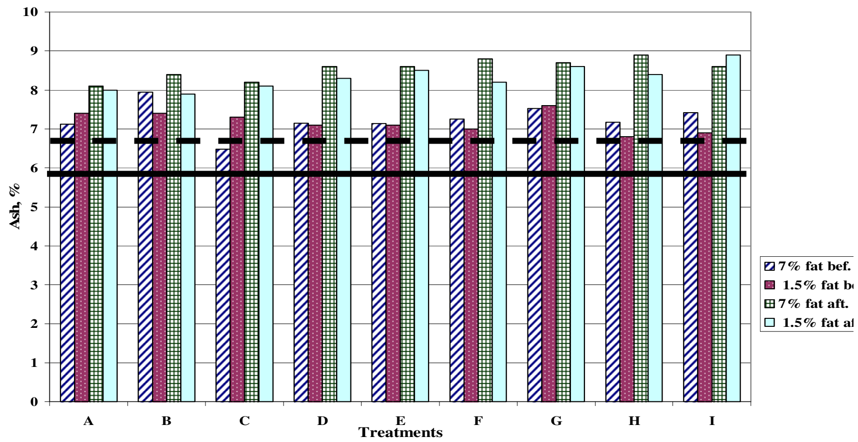
It was observed from table (3) that, the values of pH for all treatments at the two levels of fat (7% and 1.5%) before the development of the extruder were more than that of the imported texturized soybean, but the values of pH for the treatments at 1.5% fat were less than those of the



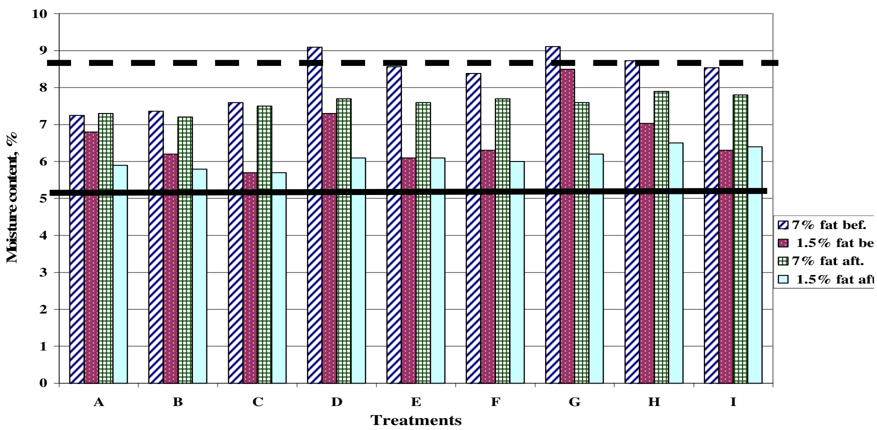
(a)Protein, %



(b) Total carbohydrates, %



(c) Ash,%



(d)Moisture content, %

Imported texturized soybean — locally texturized soybean

Fig.(11): The chemical composition of texturized soybean at 7% and 1.5% fat for different treatments before and after the extruder development.

Treatments at 7% fat, while the values of pH after the development of the extruder for all treatments at the two levels of fat (7% and 1.5%) were more than that of the imported texturized soybean, but the values of pH for the treatments at 1.5% fat were less than those of the treatments at 7% fat, and were more closer to that of the imported texturized soybean.

Also, the values of bulk density before the development of the extruder for all treatments at the two levels of fat (7% and 1.5%) were more than that of the imported texturized soybean, except the values of treatments B and F at 1.5% fat, since they were less than that of the imported texturized soybean, and the value of treatment I at 7% fat was equal to that of the imported texturized soybean. On the other hand, the values of the bulk density after the development of the extruder for all treatments at 7% fat were more than that of the imported soybean texturized, except the value of treatments E since it was less than that of the imported texturized soybean, and the value of treatment H which was equal to that of the imported texturized soybean. The values of bulk density for the treatments A, D, G, and H at 1.5 % fat were more than that of the imported texturized soybean, but the values of bulk density at the treatments B, C, E, F, and I at 1.5 % fat were less than that of the imported texturized soybean.

It was observed from table (3) that the values of hardness before the development of the extruder for the treatments at 7% fat were less than that of the imported texturized soybean, but the values of hardness for treatments C and D at 7% fat were more than that of the imported soybean texturized.

Table (3): The measured physical properties of the texturized soybean for different treatments, besidebthose the locally produced and imported texturized soybean.

Symbol*	pH				Bulk density, g/l				Hardness, N				Water absorption capacity, %			
	7% fat		1.5% fat		7% fat		1.5% fat		7% fat		1.5% fat		7% fat		1.5% fat	
	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.
A	8.2	7.01	7	6.8	494	404	346	336	10.16	6.8	21.5	15.2	210.13	387.82	367.55	390.58
B	8.9	7.02	7.6	6.9	467	373	285	232	14.16	6.3	30.9	11.3	240.96	384.14	344.75	412.01
C	8.3	6.9	7.2	6.6	442	346	327	292	19.24	7.2	39.8	20.6	237.89	375.43	365.80	397.51
D	8.3	7.1	7.1	6.8	442	326	324	356	22.14	14.7	12.9	18.6	256.47	335.09	367.50	420.65
E	9.1	7.1	7.5	6.9	431	319	327	237	13.88	13.3	18.4	27.2	265.00	389.59	409.55	458.98
F	8.3	7.1	7.1	6.7	450	373	319	319	14.19	13.7	43.4	23.4	247.52	349.45	422.00	406.47
G	8.1	7.02	7	6.9	434	369	295	354	17.8	9.3	16.6	15.5	232.39	348.96	355.50	403.89
H	8.7	7.2	7.8	7.1	455	321	347	381	11.2	10.8	19.9	17.6	240.18	360.99	382.50	402.26
I	8.2	7	7.2	6.6	421	338	332	257	16.41	8.7	29.7	19.8	272.10	347.67	353.20	419.24
locally texturized	8.7				485				11.6				265			
imported texturized	6.7				321				18.7				400.7			

Also, the values of hardness for all treatments at 1.5% fat were more than that of the imported texturized soybean, but the values of hardness for treatments D and E at 1.5% fat were less than that of the imported texturized soybean, while the values of the hardness after the extruder screw development for all treatments at 7% fat were less than that of the imported texturized soybean, but the values of the hardness after the extruder screw development for treatments C, E and F at 1.5 % fat were more than that of the imported soybean texturized. Also, the values of the treatments A, B, and G at 1.5% fat were less than that of the imported texturized soybean.

Table (3) also shows that the values of water absorption capacity before extruder screw development for all treatments at the two levels of fat (7% and 1.5%) were less than that of the imported texturized soybean, except the values of treatments F and F at 1.5% since they were more than that of the imported soybean texturized. The values of water absorption capacity for all the treatments at 1.5% fat were more than those of the treatments at 7% fat, while the values of water absorption capacity after extruder screw development for all treatments at 7% fat were less than that of the imported texturized soybean. Also, the values of water absorption capacity for all treatments at 1.5% fat were more than that of the imported texturized soybean except the values of treatments A and C at 1.5% fat since they were less than that of the imported texturized soybean.

These results indicate that the aggregates for the treatments at 1.5% fat are expected to be stable due to its higher hardness, table (3), since the majority of hardness values at 1.5% fat were in the range of 18 – 30 N, and 17 – 27 N before and after the extruder screw development respectively, while the imported texturized was 18.7 N. For the level 7% fat, the aggregates are expected to be less stable, since majority of the hardness values at that level were far less, since its values ranged from 11 to 17 N, and 7 – 13 N before and after the extruder screw development. Also, the values of the bulk density for the treatments at the 1.5% fat ranged from about 320 to 345 g/l and from 230 to 350 g/l, before and after the extruder screw development, while its value for the imported texturized soybean was 321 g/l, which is very close to those above mentioned values. For the treatments at 7% fat, the bulk density values was ranging from 440 to 470 g/l and from 320 to 370 g/l before and after extruder screw developments. These results indicate that at the 7% fat, it is expected that a higher percentage of the aggregates will be within the fine size classes which could fill the spaces among the big aggregates and causes this higher value of bulk density. These higher aggregates are expected to be produced by the collapse of the bigger aggregates.

Considering the property of water absorption capacity, the treatments at the 1.5% fat had higher values, since they ranged from 350% to 420% and from 390 to 420 % before and after extruder screw development, which were close to 400.7 %, the value of the imported texturized soybean. More over, the extruder screw development causes higher values for water absorption capacity, especially for treatment E 458.98 %, treatment D 420.65% and treatment I 419.24%, since the hardness values were also high which caused more stability for the aggregates.
For the treatments at 7% fat, the values of this property were lower before the screw development, since the values ranged from 230 to 270%. But after screw development, the values of this property ranged from 350 to 380% which could be considered very close to the value of the imported texturized soybean.

3- The aggregate sizes of texturized soybean.

The distributions of the aggregate sizes of the imported and the locally produced texturized soybean are shown in table (4). It is noticed that 48.2% of the aggregates are within the sizes between 2mm and 3.35 mm. For the locally modified soybean texturized, the aggregate sizes were divided into 5 classes table (5) and table(6); more than 9.5mm, between >3.35mm and 9.5mm, between 2mm and 3.35mm, between 1.4 and less than 2 mm, and less than 1.4 mm.

Table (4): The aggregate size of the imported and the locally produced texturized soybean.

	> 3.35 mm	3.35 – 2 mm	< 2 - 1.4 mm	< 1.4 mm
Imported soybean texturized	36.6	48.2	7.6	7.6
Locally produced soybean texturized	33.6	21.5	14.1	30.8

From table (5) and table (6) it was found that the percentages of the aggregate size (between 9.5mm and >3.35mm) after the extruder screw development for all treatments at (7% and 1.5% fat) were more than that of the imported soybean texturized, while those obtained before the extruder screw development were less than that of the imported soybean texturized, except that for treatment D. These results are expected since the hardness values for the 7% fat were less than that of the imported texturized soybean either before and after extruder screw development, while these for the 1.5% fat were close to that of the imported texturized soybean, either before or after development. However the summations of the percentages of aggregates more thane 9.35mm and the percentages of the aggregates less than 9.35nn to >3.55mm show that the values of summation were almost close to that of the imported texturized soybean before extruder screw development, while the values of the summation were very high compared to the that of the imported texturized soybean, since these values reached 40% to 59% for the 7% fat treatments, and reached 70.0% to 87% for the 1.5% fat treatments. The percentage of the aggregate size > 3.35mm for the imported texturized soybean was only 36.6%. This means that the teached high temperature inside the extruder in its three zones, beside the high compaction of the cooked material, due to the changes in the inside dimensions of the extruder screw, caused the cluster of the material into bigger aggregate sizes.

It was also found that the aggregate size (between 3.35mm and 2mm) before the extruder screw development for all treatments at 7% fat were less than that of the imported soybean texturized, while those at 1.5 % fat were very greater than that of the imported texturized soybean except treatment B.

For the aggregate size (between 3.35mm and 2mm), the distribution percentages for all treatments before and after the extruder screw development were less than that of the imported soybean texturized.

It was observed that, the percentages of aggregate size (between <2mm and 1.4mm) before the extruder screw development for all treatments at 7% fat were more that of the imported texturized soybean, while those at 1.5% fat were scattered around that of the imported texturized soybean since some had higher values and some had less values. Also, the percentages of aggregate size (between <2mm and 1.4mm) after the extruder screw development for all treatments at 1.5% fat were less than that of the imported texturized soybean, while those at 7% fat had higher values than that of the imported texturized soybean except those for treatments E, F, and H.

From table (5), it was found that the percentages of aggregate size (less than 1.4mm) before the extruder screw development for all treatments at (7% and 1.5% fat) were more than that of the imported soybean texturized except those of the treatments D, E, G, and I.

From table (6), it was found that the percentage of aggregate size (less than 1.4mm) after the extruder screw development for all treatments at (7% and 1.5% fat)were higher than that of the imported texturized soybean, except for the treatments of A, B, C, and F at 1.5% fat.

Table (5): The distribution percentages of the aggregate sizes of the modified texturized soybean before the extruder screw development.

Symbol	≥ 9.35 , mm		<9.35 - >3.35, mm		3.35 - 2, mm		<2 - 1.4, mm		< 1.4, mm	
	7% fat	1.5% fat	7% fat	1.5% fat	7% fat	1.5% fat	7% fat	1.5% fat	7% fat	1.5% fat
A	10.1	1.5	25.5	27.4	17.7	50.5	12.8	12.1	33.9	8.5
B	4.1	7.3	27.7	21.3	24.2	43.9	17.1	8.7	26.9	18.8
C	0	9.8	9.8	13.2	37.3	60.8	19.1	3.6	33.8	12.6
D	7.8	6.4	52.5	10.5	15.9	66.4	9.7	10.1	14.1	6.6
E	4.2	15.6	33.7	7.7	23.3	71.8	11.3	2.1	27.5	2.8
F	0	4.9	16.4	17.5	23.3	63.2	19.7	6.3	40.6	8.1
G	0	6.7	17.1	17.2	21.4	66.9	18.1	3.8	43.4	5.4
H	0	5.3	16.6	21.5	26.9	51.3	20.2	9.3	36.3	12.6
I	0.6	14.7	22.9	12.3	25.8	62.7	21.5	4.2	29.2	6.1

Table (6): The distribution percentages of the aggregate sizes of the modified texturized soybean after the extruder screw development.

Symbol*	≥9.35 , mm		<9.35 - >3.35, mm		3.35 - 2, mm		<2 - 1.4, mm		< 1.4, mm	
	7% fat	1.5% fat	7% fat	1.5% fat	7% fat	1.5% fat	7% fat	1.5% fat	7% fat	1.5% fat
A	5.7	10.7	39.6	70.4	17.4	8.9	10.1	2.9	27.2	7.1
B	5.4	11.7	40.7	68.6	18.2	11.4	10.5	3.3	25.2	5.0
C	5.2	12.6	42.7	67.7	22.5	10.5	8.1	3.6	21.5	5.6
D	3.3	8.5	36.9	65.2	22.5	11.9	10.5	4.1	26.8	10.3
E	6.1	7.1	51.5	65.4	17.2	15.2	5.7	4.5	19.5	7.8
F	5.8	8.9	53.2	68.7	17.9	11.8	6.7	3.9	16.4	6.7
G	4.6	8.9	44.8	70.4	22.2	9.6	7.6	3.5	20.8	7.6
H	6.7	4.4	53.2	65.6	19.3	14.8	4.7	5.3	16.1	9.9
I	5.6	11.4	41.8	65.3	19.8	11.9	7.6	3.7	25.2	7.7

CONCLUSION

The obtained results from this work showed the following:

1. The values of protein for all the treatments at I.5% fat before and after the extruder screw development were higher than that of those at 7% fat.
2. The physical properties for the treatments D, E, and F after the extruder screw development at 1.5% fat were resemble or close to those of the imported texturized soybean.
3. The results indicate that the percentage of the fine aggregates sizes for the treatments at 1.5% fat after the extruder screw development were scattered around that of the imported texturized soybean.

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الملخص العربي

تحسين خواص المنتجات المبثوقة المصنعة محليا من فول الصويا

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في اطار البحث عن بدائل اللحوم الطبيعية يأتي فول الصويا في مقدمة هذه البدائل وذلك لاحتوائه على نسبة كبيرة من البروتين. واستخدام دقيق الصويا كاضافات في تصنيع اللحوم يؤدي الى تحسين الاحتفاظ بالماء الممتص ويقلل من حدوث انكماش الطبخ وبالتالي تحسين شكل المنتج النهائي ورفع قيمته الغذائية وتقليل التكلفة الاقتصادية.

وقد تمت الدراسة على الة البثق الحراري احادي الحلزون مع التغير في مستويات الزيت لدقيق الصويا المستخدم والمحتوى الرطوبي له ونوع القلوي المستخدم ووجد ان:

1- التصميم الجديد للحلزون رفع درجه الحرارة في مرحلة التغذية الى 90°م ، وفي مرحلة العجن الى 140 °م ، اما المرحلة الاخيره هي مرحلة الطبخ فقد وصلت درجة الحرارة الى 170 °م.
2- وجد ان هناك علاقة بين نسبة الزيت في دقيق الصويا ونسبة البروتين والمحتوى الرطوبي؛ فعندما تقل نسبة الزيت في الدقيق تزيد نسبة البروتين وتقل نسبة المحتوى الرطوبي.
3- اظهرت النتائج الخاصة بالتصميم الجديد للحلزون عند نسبة زيت 1.5% ان المنتج المبثوق كان اكثر ثباتا واكثر صلابة وبالتالي حدث تحسن في خواصه حيث زادت درجة تشربه للماء، وزادت نسبة الحبيبات ذات الحجم المرغوب فيه في تصنيع اللحوم.

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