IMPROVING THE PROPERTIES OF MEAT ADDITIVES PRODUCED FROM DIFFERENT SOY BEAN BLENDS BY THE SINGLE SCREW EXTRUDER

Morcos M. A. [*], *B. M. A. Amer*[*], *H. K. El-Manawaty*[**]
and M. M. H. Zakzouk[**]

ABSTRACT

Processing parameters for improving meat additives produced from soy bean blends were applied including the use of blends of soy bean – faba bean of different ratio (33.3:66.6, 50:50, 66.6:33.3, and 75:25%) and different moisture contents of (15, 20, 25, and 30%). Operation parameters of extruder were also applied as barrel temperature without appling any thermal insulation at its three zone (feeding, kneading, and cooking) (90, 140, 170°C) and barrel temperature at its three zone after providing thermal insulation for its barrel (95, 145, 175°C) and different dies with three diameters (6, 8, and 10 mm) and three lengths of die (45, 65, and 85mm). Those applied parameters were provided for evaluating their effect on the chemical and engineering properties of the produced texturized from (soy bean- faba bean) blends. The properties of the produced texturized additives from (soy bean- faba bean) at 50:50% at moisture content 20% accompanied by providing thermal insulation for the barrel housing and die's diameter 6mm and its length 85mm were the best.

INTRODUCTION

Today, the extruder became one of the most important machines in food processing, since it is used for making pasta, breakfast cereals, baby food, snacks food, confectionery items, pet food, extraction of oil and texturized protein (***Linko et al. ,1983).***

Soybean came the first of the natural alternates for meat, because it is high in protein "containing 38%" by weight and oil makeing up about 18% of the weight of soybean seeds (***U.S.B, 2004)***.

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* Ag. Eng. Dept., Faculty of Agriculture, Cairo University.
**Food Eng. Dept., Food Technology Research Institute, Agricultural Research Center.

The locally produced texturized soybean is containing 7% fat but the imported one is containing 0.5% fat; because in abroad it is acceptable to remove the fat by solvent, but the solvent is unacceptable in Egypt since it is: (1) expensive , (2) it's residual affect the quality of the product, and (3) it changes the chemical component of the product.

To reduce the effect of fat, a suggestion of the addition of some legumes which contain low amount of fat was proposed to make soy flour blends having low fat content, since the high content of fat has the effects:

1. Decreasing the coefficient of viscosity which will be reflected in decreasing the internal friction between the raw material and the material of the machine.

2. Increasing the fat ratio in the final product which will be reflected in decreasing in water absorption capacity and this will affect the quality of the final product.

The nutritional value of bean "faba-bean" has been traditionally attributed to it high protein content, which ranges from 25 to 35%, despite the imbalance in sulphur aminoacids. Most of these proteins are globulins (60%), albumins (20%), glutelins (15%) and prolamins. It is also a good source of sugars, minerals and vitamins. The chemical analysis of this legume reveals a 50- 60% content of carbohydrate, which is mainly constituted by starch, while the proportion of lipids is relatively low at about l-2.5% with oleic and linoleic acids representing about 75% of fats (*Larralde and Martinez, 1991*).

Liang et al., (**2009**) mentioned that water absorption capacity for meat additives produced by the extruder increased with feed moisture, barrel temperature, and screw speed. Each of these also contributed to the higher expansion ratio and the lower bulk density. Higher expansion ratio means higher porosity of the sample and hence greater ease for rehydration. All these conditions are indicative of higher and more rapid expulsion of moisture due to the larger pressure difference and higher temperature at the die.

Chakraborty and Banerjee (2009) found that the effect on the expansion ratio by changing die temperature and feed moisture, were significant in

the first order effect of feed moisture, and second order effect of feed moisture and temperature. Increasing feed moisture and temperature, expansion ratio increased at 15% moisture content and 181.5°C die head temperature and decreased subsequently with the rise in temperature and moisture content. On increasing temperature, gelatinization of starch was more and raised expansion ratio, and with further increase of temperature, starch fragmentation occurred and reduced expansion ratio. Longitudinal expansion and elasticity factors were related with expansion ratio.

This research has been undertaken to study the effect of decreasing heat lose in single screw extruder to improve the properties of extrudates produced from different flour blends at soy bean: faba bean ratios.

MATERIALS AND METHODS

A single screw extruder was used in this study to produce the locally texturized soybean. The performance of the extruder depends upon both the high pressure imposed by the extruder on soybean flour and the increase of the generated temperature by the frication between extruder inside surfaces and soybean flour. The temperature of the processed material inside the extruder during the process was found to be 140ºC. The extruder drive is a 50HP electric motor. Speed reduction and torque transfer are accomplished through the use of belts. The feeding device of the extruder is a one HP side mounted motor. The fed material is pumped by the screw of the feeding device into the extruder barrel which is also accompanied with a mixing shaft. The extruder barrel assembly consists of a stationary barrel housing, a rotating screw and steamlocks, and die. The extruder barrel housing has inside axial groove design, to insure the slip of the fed material. The extruder's screw geometry influences mixing, kneading, and cooking of the fed material by the developed heat and pressure. The movement and transformation of the fed 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. In previous work the specifications of each of the three screw parts were developed and these three parts were fabricated. The specifications of the extruder's screw are listed in Table (1), (**Morcos et al., 2007**). 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 0.8 cm.

Table (1): The specifications of the developed screw and that of the barrel of the applied extruder.

Dimensions	Feeding zone	Kneading zone	Cooking Zone
Pitch (cm)	3.55	2.6	1.75
Inside diameter (cm)	7.1	7.4	7.7
Outside diameter (cm)	9.2	9.2	9.2
Piece length (cm)	12.74	12.74	12.74
Inside obtained temperature (ºC)	90	140	170
Steamlocks thickness (cm)	1.905	1.905	1.905
Inlet steamlock diameter (cm)	8.225	8.575	9.207
Outlet steamlock diameter (cm)	8.575	9.207	9.525

Table (2): The specification of barrel housing and isulated materials.

Description	Unite	Feeding zone	Kneading zone	Cooking zone
Length of zone, L	m	0.1263	0.1263	0.1263
Outer diameter, D_1	m	0.133	0.133	0.133
Inner diameter, D_2	m	0.10812	0.10812	0.10812
Ambient temperature, T_3	°C	25	25	25
Wall temperature, T_2	°C	98	136	164
Soybean temperature, T_1	°C	90	140	170
Material of insulation		Glass wool	Glass wool	Glass wool
Thermal conductivety of barrel material, k_B	W/m°C	54	54	54
Thermal conductivety of insulation material, k_{in}	W/m°C	0.038	0.038	0.038
Thermal conductivety of soybean, k_s	W/m°C	0.3331	0.3331	0.3331
Convection heat transfer coefficient, h_1	W/m²°C	1843.5	1843.5	1843.5

The modification of the barrel housing of the single screw extruder

An insulation in the form of a cylindrical tube was added around the barrel housing. The insulation has two different effects. The additional insulation decrease the rate of the conduction heat transfer of the insulation layer but increases the convection rate of heat transfer of the surface because of the increase in the outer surface area for convection. The heat transfer from the pipe may increase or decrease, depending on which effect dominates.

Considering an insulation cylindrical pipe of outer radius r_3 whose outer surface temperature T_3 is maintained constant, Fig (1) . The barrel is now insulated by a tube of an insulating material with thermal conductivity of k_{in}. Heat is lost from the outer surface of the insulating tube to the surrounding medium at temperature T_3 , with convection heat transfer coefficient h_3. The rate of heat transfer from the outer surface of the insulated tube to the surrounding air can be expressed as (**Kumar, 2012**):

$$Q = \frac{T_3 - T_1}{\frac{1}{(2\pi r_1 \ L) h_1} + \frac{\ln\frac{r_2}{r_1}}{2\pi L k_b} + \frac{\ln\frac{r_3}{r_2}}{2\pi L k_{in}} + \frac{1}{(2\pi r_3 L) h_3}} \qquad (1)$$

Where:

T_1 : inner surface temperature of barrel, °C

T_2 : outer surface temperature of barrel, °C

T_3 : surrounding medium at temperature, °C

r_1 : inner radius of barrel housing, m

r_2 : outer radius of barrel housing, m

r_3 : outer radius of insulated barrel housing, m

L : length or barrel housing, m

K_{in} : thermal conductivity of insulation, W/m°C

K_B : thermal conductivity of barrel, W/m°C

h_1 : convection heat transfer coefficient at barell, W/m^2°C

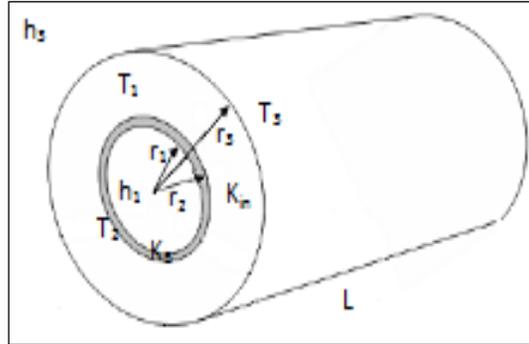h_3:convection heat transfer coefficient to the surrounding, W/m^2°C

Fig .1. The insulation cylindrical pipe surrounding the extruder barrel.

Heat transfer coefficient of the soybean can be calculated by, *(Heldman and Lund, 2007, Lienhard, 2008, Cengel and Ghajar, 2011)* and *Wikipedia, 2012):*

$$Nu = \frac{h_1 \, H}{k_s} \qquad (2)$$

$$Nu = 0.023 \, R_e^{0.8} \, P_r^{0.4} \qquad (3)$$

$$R_e = \frac{\rho \, V_m \, D}{\mu} \qquad (4)$$

$$P_r = \frac{C_p \, \mu}{k} \qquad (5)$$

Where:

Nu : Nusselt number

H : Channel depth, m

R_e : Reynolds number

P_r : Prandtl number

ρ : Bulk density of dough, kg/m^3

V_m : mean fluid velocity, m/s

μ : Viscosity, pa.s

C_p : Specific heat of soybean, k Cal / kg °C

Heat transfer coefficient of the barrel can be calculated by, (**Wikipedia, 2012**):

$$h_3 = \frac{k_{in}}{thickness} \qquad (6)$$

k_{in} : Thermal conductivety of insulation material,

Table (3): the values of heat transfer coefficient of the barrel at different thickness of insulation:

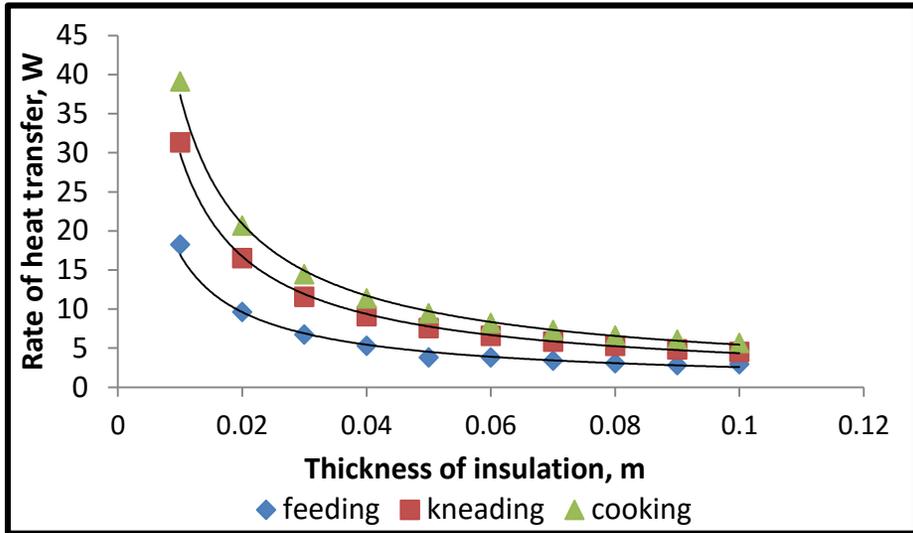| Thickness, m	0.01	0.02	0.03	0.04	0.05	0.06
h_3	3.8	1.9	1.266	0.95	0.76	0.63

Fig .2. The rate of heat transfer from the insulated barrel to the surrounding air.

The applied diameter of insulation on the extruder's barrel was 0.1m shown in Fig (3), and then evaluated the texturzed with different treatments.

Fig .3. Applied the critcal radius of insulation on the extruder's barrel.

The modification of the die of the single screw extruder

Nine dies were used in single screw extruder. Three different lengths of die were used with three different diameters. The best treatments of blends (soy bean – faba bean) and moisture content were applied by the different dies to choose the best one of dies. The shape of the die is shown in fig (4). The different dimensions of die are showing in table (4).
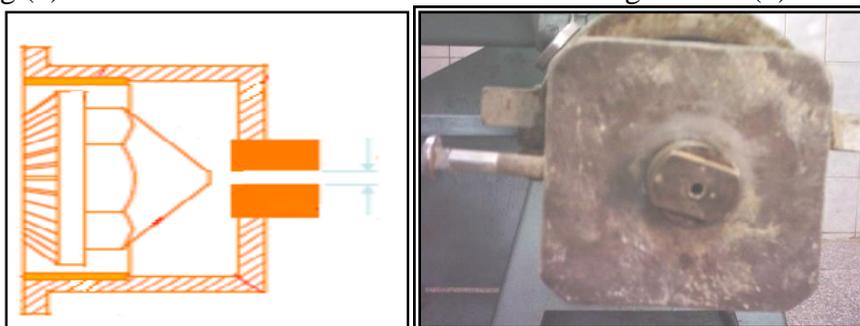

Fig. 4. The parts and a photo for the extruder's die area and the die.

Table (4): The specifications of the developed dies.

Symbol	Die	
	Length, mm	Diameter, mm
1	45	6
2	45	8
3	45	10
4	65	6
5	65	8
6	65	10
7	85	6
8	85	8
9	85	10

Calculation and Laboratory Measurements

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

4. Expansion ratio was determined by dividing mid point diameter of the extrudate grain by the diameter of die hole.

5. The bulk density was calculated from equation

$$D_b = m / V \qquad (8)$$

where :

D_b = The bulk density of soybean texturized, g /cm^3

m = The mass of soybean texturized, g

V = The volume of soybean texturized, cm^3

6. The soybean texturized hardness was determined using a digital force gauge.

7. The rotating speed of the used screw was determined using hand digital tachometer.

8. The temperature was determined using digital thermometers.

RESULTS AND DISCUSSION

1- Chemical Components of the different soy bean blends (Soybean and faba bean)

The chemical components of the imported texturized soybean of: fat content, protein, total carbohydrates, ash, and moisture content are 0.5, 67.5, 19.5, 6.6, and 5.9% respectively. Also, those for the locally produced ones are 7, 47.1, 29.8, 7.3, and 8.8%, respectively. The chemical components of the modified texturized soybean (18% moisture content+CaCO$_3$ 1%) were 1.5, 48.89, 35.31, 8.2, and 6% respectively (**Morcos et al., 2007**). The average values of the chemical components for the soybean blends with the blend ratios of bean 66.6:33.3, 50:50, 33.3:66.6, and 25:75 are shown in table (5). The value of protein content for the imported texturized soybean was 67.5% and that value of the locally produced texturized was 47.1%, while the value of the local soybean texturized after the removed fat with solvent was 48.89%. However, the average value of protein at those blend ratio of (66.6% bean + 33.3% soybean, blend ratio of (50% bean + 50% soybean) , blend ratio of (33.3% bean + 66.6% soybean) and blend ratio (25% bean + 75% soybean) were ≈57.7, 54.5, 48.6, and 46.8%, respectively. So, increasing the percentage of the bean in the blends resulted in increasing the

percentage of the protein in the locally produced and tested texturized soy bean blends.

Table (5): Chemical Components of Soybean blends

Chemical Component	Percentage of Blend			
	66.6% Bean + 33.3% Soybean	50% Bean + 50% Soybean	33.3% Bean + 66.6% Soybean	25% Bean + 75% Soybean
Protein %	57.7	54.5	48.6	46.8
Fat %	2.22	2.95	4.65	6.83
Ash %	8.9	9.17	9.32	9.58
Carbohydrates %	25.5	26.28	29.55	30.15

The value of fat content for the imported texturized soybean was 0.5% and that value for the locally texturized was 7%, while that value for the locally produced texturized soybean after the removal of fat with solvent was 1.5%. However, the average value of fat at the blend ratio of (66.6% bean + 33.3% soybean), blend ratio of (50% bean + 50% soybean) , blend ratio of (33.3% bean + 66.6% soybean) and blend ratio of (25% bean + 75% soybean) were ≈2.22, 2.95, 4.65, and 6.83%. So, increasing the percentage of the bean in the blends resulted in decreasing the percentage of fat in the locally produced and tested texturized soy bean blends.The value of ash content for the imported texturized soybean was 6.6% and that value for the locally texturized was 7.3%, while that value for local texturized after the removal of fat with solvent was 8.2%. However, the average value of ash content at the blend ratio of (66.6% bean + 33.3% soybean) was ≈8.9%, while the average value of ash content at the blend ratio (50% bean + 50% soybean), blend ratio of (33.3% bean + 66.6% soybean), and blends ratio of (25% bean + 75% soybean) were ≈8.9, 9.17, 9.32, and 9.58% respectively. The value of the carbohydrates content for the imported texturized soybean was 19.5% and that for the locally texturized was 29.8%, while that for local texturized after the removal of fat with solvent was 35.31%. However,

the average value of the carbohydrates content at the blend ratio of (66.6% bean + 33.3% soybean), blend ratio of (50% bean + 50% soybean), blend ratio of (33.3% bean + 66.6% soybean) and blend ratio of (25% bean + 75% soybean) were ≈25.5, 26.28, 29.55, and 30.15%, respectively.

2- Physical Properties of the Modified Texturized (Soybean – faba Bean) blends Before and After applying Extruder's Heat Insulation.

The pH of the modified texturized soybean blends

The average values of pH for the texturized blends of soybean for the different treatments with the blend ratio of bean 66.6:33, 50:50, 33.3:66.6, and 25:75 are shown in Table (5). The value of pH for the imported texturized soybean was 6.7 and that for the local texturized was 8.7. From table (6), the average value of pH at the un-insulated treatments A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, and P were ranging between 6.8 and 6.9, while those of the insulated treatments were ranging between 6.6 and 6.8.

The bulk density (ρ_b) of the modified texturized soybean blends

The value of bulk density for the imported texturized soybean blends was 321g/l and those value for local texturized was 485g/l. However, the average value of bulk density at the non insulated treatments A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, and P were ranged 210.5 to 381.5g/l. While the average value of bulk density at the insulated were ranged 220.5 to 360.5g/l.

These results indicate that the aggregates of the treatments at the blend ratio (50% bean + 50% soybean) could be more stable due to its expect higher hardness, and the interspaces between them are not filled with the powder of the texturized flour or the small aggregates, which could be produced by the collapse of the produced grains.

Table (6): The physical properties of soybean texturized.

symbol	pH		Bulk density, g/l		Hardness, N		Water absorption capacity, %		Expansion ratio	
	Ins.	Non.	Ins.	Non.	Ins.	Non.	Ins.	Non.	Ins.	Non.
A	6.60	6.8	220.50	210.50	18.10	16.50	399	396	4.81	4.71
B	6.70	6.9	236.80	214.36	18.90	17.20	400	399	4.75	4.66
C	6.60	7.01	235.36	220.69	19.50	17.90	407	402	4.71	4.61
D	6.60	6.8	251.69	230.50	20.10	18.10	410	408	4.67	4.58
E	6.68	7.02	329.13	326.20	20.45	18.36	420	410	5.05	4.95
F	6.70	6.94	334.10	330.50	25.62	22.30	418	408	4.95	4.85
G	6.50	6.97	338.90	333.20	27.69	25.00	415	405	4.77	4.69
H	6.50	6.81	342.50	338.40	28.74	26.00	410	400	4.61	4.66
I	6.70	6.72	332.10	340.82	25.83	22.00	405	400	4.95	4.45
J	6.79	6.83	337.10	344.60	28.96	24.30	400	398	4.64	4.23
K	6.83	6.94	339.70	348.71	28.53	26.40	397	381	4.3	4.19
L	6.70	6.89	341.07	354.27	30.53	28.10	393	378	4.23	4.11
M	6.8	6.86	348.13	358.23	29.43	28.80	387	380	3.70	3.76
N	6.82	6.96	350.60	368.20	32.30	30.80	380	377	3.34	3.71
O	6.75	6.85	355.06	375.60	39.79	32.60	372	371	3.30	3.67
P	6.80	6.86	360.50	381.50	40.75	37.80	370	365	3.26	3.58

Table (7): Mathematical equations and R^2 expressing the relationship between moisture content and bulk density for the different of soybean blends before and after applying extruder heat insulation.

Blend ratio	The equation (before extruder heat insulation)	R^2
66.6% Bean	$y = 0.0842x^2 - 2.3149x + 226.45$	0.9979
50.0% Bean	$y = -0.4279x^2 + 26.372x - 65.39$	0.9854
33.3% Bean	$y = -0.5853x^2 + 30.847x - 47.431$	0.9474
25.0% Bean	$y = 0.8393x^2 - 30.945x + 638.01$	0.9503
	The equation (after extruder heat insulation)	
66.6% Bean	$y = 0.0654x^2 + 5.1665x + 247.23$	0.8446
50.0% Bean	$y = -0.0363x^2 + 2.2237x + 306.97$	0.9985
33.3% Bean	$y = -0.3672x^2 + 22.342x + 4.5467$	0.9863
25.0% Bean	$y = 0.0003x^2 + 1.8291x + 194.77$	0.8707

x= moisture content %, y= bulk density g/l

The hardness (H_t) of the modified texturized soybean blends

The average values of the hardness (H_t) for the modified texturized (bean + soybean) before and after extruder heat insulation are shown in Table (6). The value of hardness for the imported texturized soybean was 18.7 N and those value for local texturized was 11.6 N. However, the average value of hardness at the non insulated treatments A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, and P were ranged from 16.5 to 37.8 N. While the average value of hardness at the insulated treatments were ranged from 18.1 to 40.7 N. These results indicate that the aggregates of the treatments at the blend ratio (66.6% bean + 33.3% soybean) and (50% bean + 50% soybean) are expected to be more stable due to its higher hardness, and the percentages of powder of the soybean texturized are lower than those of the other blends. Figs, (5 & 6) show the relation of the hardness and moisture content of the modified texturized (soybean – bean) for the different treatments before and after extruder heat insulation. The second degree polynomial equation obtained by effect of feed moisture content versus hardness at different ranges of blend ratio before and after insulated are shown in Table (8).

Table (8): Mathematical equations and R^2 expressing the relationship between moisture content and hardness for the different of soybean blends before and after applying extruder heat insulation.

Blend ratio	The equation (before extruder heat insulation)	R^2
66.6% Bean	$y = -0.005x^2 + 0.335x + 12.575$	0.9921
50.0% Bean	$y = -0.0294x^2 + 1.8354x - 2.579$	0.9997
33.3% Bean	$y = -0.006x^2 + 0.678x + 13.17$	0.9999
25.0% Bean	$y = 0.032x^2 - 0.864x + 34.74$	0.9855
	The equation (after extruder heat insulation)	
66.6% Bean	$y = -0.002x^2 + 0.222x + 15.23$	0.9991
50.0% Bean	$y = -0.0412x^2 + 2.3928x - 6.068$	0.9947
33.3% Bean	$y = -0.0113x^2 + 0.7819x + 16.944$	0.8434
25.0% Bean	$y = -0.0191x^2 + 1.6885x + 7.8425$	0.9332

x= moisture content %, y= hardness

The water absorption capacity (WAC) of the modified texturized soybean blends

The results of the water absorption capacity (WAC) of the modified soybean texturized for all treatments before and after extruder heat insulation are shown in Table (6). The value of WAC for the imported texturized soybean was 400.7% and those value for local texturized was 265%. However, the average value of WAC at the non insulated treatments A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, and P were ranged from 396 to 410%. While the average value of WAC at the insulated treatments were ranged from 399 to 420%. These results show that the presence of fat affected water absorption capacity. From this point of view, the imported texturized soybean had the highest water absorption capacity, since its fat content is only 0.5%, beside its high hardness value which causes its aggregates to be stable and prevents its collapse. Figs, (7 & 8) show the relation of the WAC and moisture content of the modified texturized (soybean – bean) for the different treatments before and after extruder heat insulation. The second degree polynomial equation obtained by effect of feed moisture content versus WAC at different ranges of blend ratio before and after insulated are shown in Table (9).

Table (9): Mathematical equations and R^2 expressing the relationship between moisture content and WAC for the different of soybean blends before and after applying extruder heat insulation.

Blend ratio	The equation (before extruder heat insulation)	R^2
66.6% Bean	$y = -0.0253x^2 + 0.6652x + 412.15$	0.9984
50.0% Bean	$y = 0.1176x^2 - 6.9779x + 486.9$	0.9927
33.3% Bean	$y = -0.0458x^2 + 0.6171x + 399.1$	0.8338
25.0% Bean	$y = -0.03x^2 + 0.33x + 381.95$	0.9966
	The equation (after extruder heat insulation)	
66.6% Bean	$y = -0.0059x^2 + 0.4898x + 388.48$	0.9988
50.0% Bean	$y = -0.0409x^2 + 1.658x + 387.49$	0.8069
33.3% Bean	$y = 0.0061x^2 - 1.061x + 419.45$	0.9978
25.0% Bean	$y = 0.0002x^2 - 2.0354x + 428.87$	0.8615

x= moisture content %, y= WAC %

The expansion ratio of the modified texturized soybean blends

The results of the expansion ratio of the modified soybean texturized for all treatments before and after extruder heat insulation are shown in

Table (6). The average value of expansion ratio at the non insulated treatments A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, and P were ranged from 3.58 to 4.95 While the average value of WAC at the insulated treatments were ranged from 3.26 to 5.05. Figs (9 & 10) show the relation of the expansion ratio and moisture content of the modified texturized (soybean – bean) for the different treatments before and after extruder heat insulation. The second degree polynomial equation obtained by effect of feed moisture content versus expansion ratio at different ranges of blend ratio before and after insulated are shown in Table (10).

Table (10): Mathematical equations and R^2 expressing the relationship between moisture content and expansion ratio for the different of soybean blends before and after applying extruder heat insulation.

Blend ratio	The equation (before extruder heat insulation)	R^2
66.6% Bean	$y = 0.0002x^2 - 0.0178x + 4.933$	0.998
50.0% Bean	$y = 0.0058x^2 - 0.3159x + 8.3736$	0.9884
33.3% Bean	$y = 0.0014x^2 - 0.0842x + 5.387$	0.9619
25.0% Bean	$y = -0.0004x^2 + 0.0064x + 3.751$	0.9897
	The equation (after extruder heat insulation)	
66.6% Bean	$y = -0.0007x^2 + 0.0367x + 4.4222$	0.9994
50.0% Bean	$y = -0.0006x^2 - 0.003x + 5.235$	0.9956
33.3% Bean	$y = 0.0024x^2 - 0.158x + 6.795$	0.9864
25.0% Bean	$y = 0.001x^2 - 0.147x + 6.5724$	0.9176

x= moisture content %, y= expansion ratio

3- Physical properties of the modified texturized (Soybean – faba Bean) blends with different dies after applying extruder's heat insulation.

After applied the blends of (soybean – faba bean) at different ratio (33.3:66.6, 50:50, 66.6:33.3, and 75:25) and different moisture content (15, 20, 25, and 30%). These treatments applied in the single screw extruder with thermal insulation and without thermal insulation at three zones of barrel (feeding, kneading, and cooking). It was found that the best treatments of blends were E (50% soy bean : 50% faba bean +

moisture content 20%) and F (50% soy bean : 50% faba bean blends + 25%) were used with different dies in Table (4). The values of physical properties for texturized are shown in Table (11).

The physical properties of the imported texturized soybean were 6.7, 321g/l, 18.7N, 400.7% and the values of the locally texturized soy bean were 8.7, 485g/l, 11.6N, 265% for pH, bulk density, hardness, and water absorption capacity, respectively.

From Tables (5, 11) it was observed that the treatment F7 (50% soy bean : 50% faba bean) + 25% moisture content with die diameter 6mm and 85mm length was the best.

Table (11): The Physical properties of modified texturized (Soybean – faba Bean) blends with different dies after applying extruder's Heat Insulation.

| Symbol	pH	Bulk density, g/l	Hardness, N	Water Absorption Capacity, %	Expansion ratio
1	**2**	**3**	**4**	**5**	**6**
E1	6.66	332.6	11.4	380	4.13
F1	6.68	346.0	10.3	379	4.81
E2	6.66	355.1	12.5	377	4.23
F2	6.71	360.5	13.2	381	4.61
E3	6.80	432.6	14.2	369	4.55
F3	6.45	376.0	14.9	366	4.65
E4	6.64	332.13	20.45	410	4.13
F4	6.63	336.9	20.91	405	4.38
E5	6.57	342.5	25.01	420	4.22
F5	6.56	339.7	26.0	418	4.61
E6	6.59	408.67	27.2	415	4.51
F6	6.54	409.3	26.3	413	4.45
E7	6.66	305.6	13.6	422	5.12
F7	6.71	316.1	15.8	429	5.62
E8	6.53	330.0	15.2	419	4.95
F8	6.64	328.7	15.4	419	4.81
E9	6.59	361.7	19.9	417	4.83
F9	6.58	366.9	16.1	415	4.87
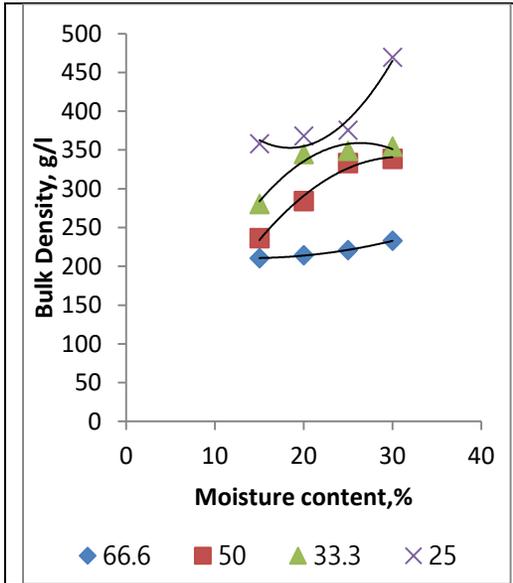
Fig.4. The relation between bulk density and the moisture content of the modified texturized soybean blends for the different treatments before applying the extruder heat insulation.
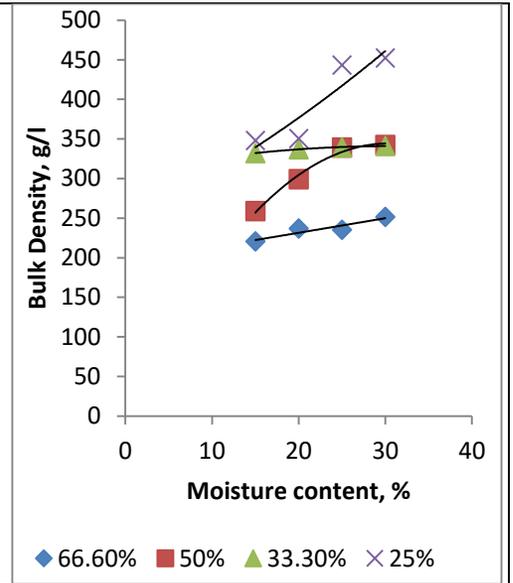

Fig.5. The relation between bulk density and the moisture content of the modified texturized soybean blends for the different treatments after applying the extruder heat insulation
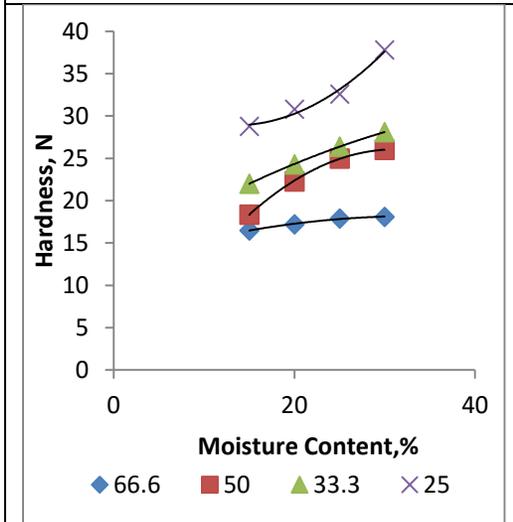

Fig.6. The relation between the hardness and the moisture content of the modified texturized soybean blends for the different treatments before applying the extruder heat insulation
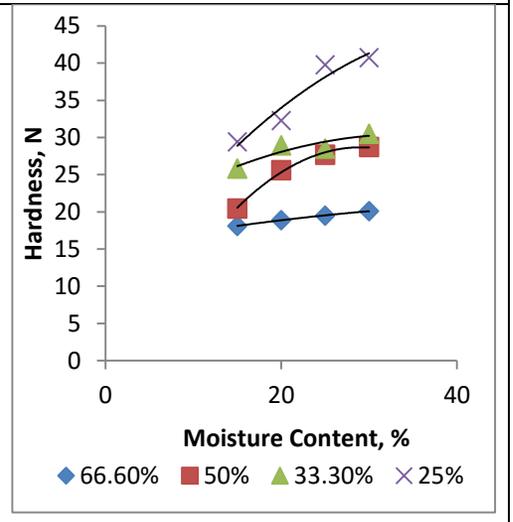

Fig.7. The relation between the hardness and the moisture content of the modified texturized soybean blends for the different treatments after applying the extruder heat insulation
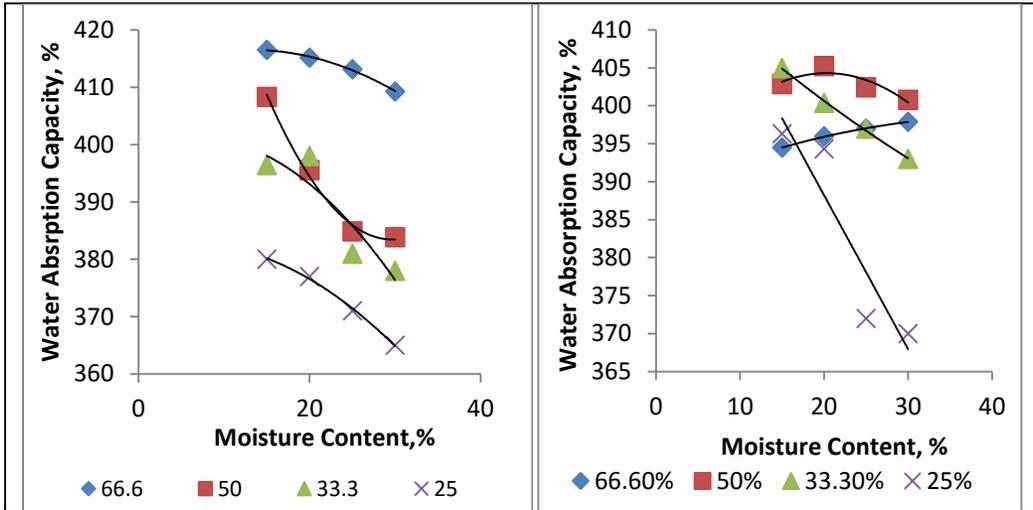
Fig.8. The relation between the WAC and the moisture content of the modified texturized soybean blends for the different treatments before applying the extruder heat insulation.

Fig.9. The relation between the WAC and the moisture content of the modified texturized soybean blends for the different treatments after applying the extruder heat insulation
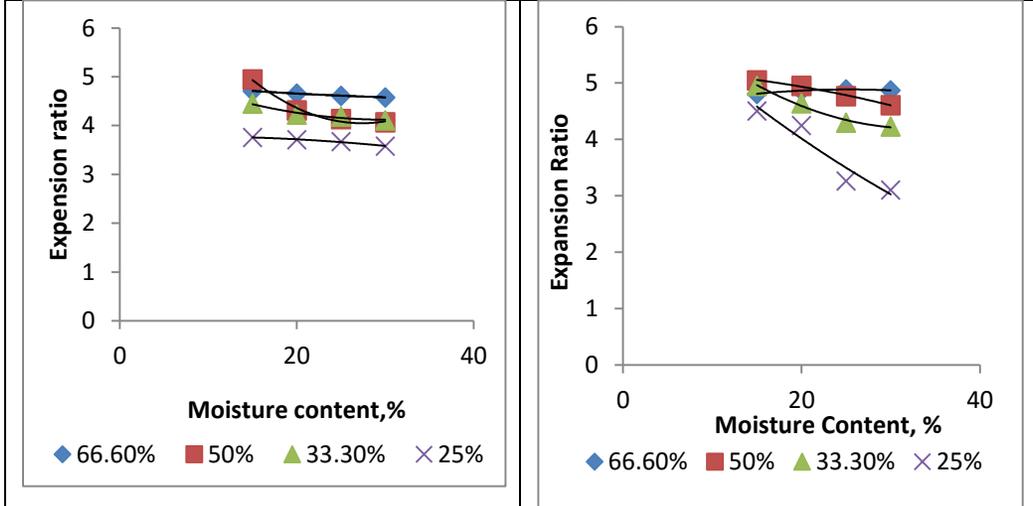
Fig.10. The relation between the Expansion ratio and the moisture content of the modified texturized soybean blends for the different treatments before applying the extruder heat insulation.

Fig.11. The relation between the Expansion ratio and the moisture content of the modified texturized soybean blends for the different treatments after applying the extruder heat insulation

CONCLUSION

Soybean came the first of the natural alternates for meat, because it is high in protein "containing 38%" by weight. The locally produced texturized soybean is containing 7% fat but the imported one is containing 0.5% fat. To reduce the effect of fat, a suggestion of the addition of some legumes (Faba bean) which contain low amount of fat was proposed to make soy

flour blends having low fat content. It was found that percentage of 50:50 (soybean: bean) is the best. To raise the temperature inside the barrel used fiber glass insulation and found that 0.10 m thickness was the best.

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<u>الملخص العربى</u>

تحسين خواص اضافات اللحوم المصنعة من خلائط مختلفة من فول الصويا بواسطة الباثق الحراري أحادي الحلزون

منير عزيز مرقص*، باهرمحمود عامر*، حسين كمال الدين المنواتي**
و مروة محمد حلمي زقزوق**

لقد أصبح الباثق الحراري اليوم واحد من أهم الاختراعات في مجال الاغذية , حيث انه يستخدم في تصنيع كثير من أنواع الأغذية المختلفة, وتتم عملية البثق الحراري للمنتج خلال عدة مراحل مختلفة وهي : الطبخ, والعجن ,والتشكيل , حيث تتم هذه المراحل تحت ظروف معينة من الانضغاط ودرجة الحرارة, وللجسم الخارجي للباثق الحراري Extruder barrel أهمية خاصة لأنه يحتوي بداخله على الحلزون وكلاهما مسؤلان معا عن الاحتكاك بين المادة الخام ومعدن الالة مما يؤدي الى زيادة انضغاط ودرجة الحرارة للمادة الخام, و تزداد ذاتيا كل من درجة الحرارة والانضغاط للمادة الخام داخليا في الباثق أحادي الحلزون نتيجة للاحتكاك الداخلي , وفي الباثق الحراري احادي الحلزون تكون درجة الحرارة والانضغاط غير كافية لاتمام عملية الطبخ , وبالتالي تكون مواصفات المنتج مختلفة وخواصه غير مطابقة لخواص المنتج المستورد المماثل له. ومن المحاولات السابقة لتحسين خواص الاضافات المنتجة محليا, العمل على تطوير مواصفات الحلزون مع تقليل نسبه الدهن لفول الصويا باستخدام المذيبات, ؛وأدى ذلك الى تحسين خواص المنتج بنسبة ملحوظة الا انه وجد ان درجة الحرارة مازالت تحتاج الى الزيادة لتحسين خواص المنتج, كما أن استخدام المذيبات في مصر غير مقبول تصنيعيا لأنه: (١) مكلف اقتصاديا , (٢) بقاياه تؤثر على جودة المنتج , (٣) تغير بعض المكونات الكيميائية للمادة المنتجة . وقد دعى ذلك الى اقتراح اضافة الفول البلدي الذي يحتوي على نسبة دهن منخفضة الى دقيق فول الصويا للعمل على خفض نسب الدهن في الخليط, اذ أن مشكلة الانتاج المحلي لبروتين الصويا المنسج باستخدام الباثق الحراري احادي الحلزون في مصر تتلخص في انخفاض درجة الحرارة داخل الباثق؛ حيث ان التطوير في مواصفات الحلزون المفرد لم يعطي الحرارة المطلوبة كما يتطلب الامر ايضا تخفيض نسبة الدهن في المنتج المبثوق. لذلك تهدف هذه الدراسة الى دراسة تأثير تطوير الجسم الخارجي للباثق الحراري احادي الحلزون Extruder barrel بعزله بمادة عازلة حراريا لزيادة درجة حرارة المادة الخام مع تغير ابعاد فتحة الخروج die, وايضا تقليل نسبة الدهن وذلك لتحسين خواص المنتج المبثوق. وقد تم عزل الجسم الخارجي للباثق الحراري Extruder barrel باستخدام الصوف الزجاجي ؛ ونتج عن ذلك تقليل الفقد الحراري وزيادة درجة الحرارة داخل الحلزون, وايضا دراسة تأثير خلط فول الصويا مع الفول البلدي بنسب ٣٣,٣:٦٦,٦ , ٥٠:٥٠ , ٦٦,٦:٣٣,٣ , ٧٥:٢٥ % على تحسين خواص المنتجات المنسجة محليا, ويوصي البحث باستخدام نسبة الخلط ٥٠:٥٠% عند مستوى رطوبة ٢٠% , ٢٥% عند قطر فتحة الخروج ٦مم وطولها ٨٥مم.

* قسم الهندسة الزراعية ـ كلية الزراعة ـ جامعة القاهرة.
* قسم هندسة التصنيع والتعبئة والتغليف ـ معهد بحوث تكنولوجيا الأغذية ـ مركز البحوث الزراعية.