EXTRUSION COOKING OF MECHANICALLY DEBONED TURKEY MEAT WITH SOY PROTEIN, KAPPA-CARRAGEENAN AND OAT FIBER

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SUMMARY

This study examined the effects of soy protein isolate (SPI; 16-26%), kappa-carrageenan (K-C; 0.3-0.9%) and oat fiber (OF; 0-3%) on the binding (cohesion) and hardness of extrusion-cooked mechanically deboned turkey meat (MDTM). The most significant factor affecting product binding was SPI level. Binding was also affected by the level of K-C and its interaction with SPI. Hardness was increased by level of OF, which had no major effect on binding. The most acceptable extrusion-cooked MDTM products had binding scores similar to that of commercial frankfurters and were formulated with 24% SPI and 0.6-0.9% K-C.

INTRODUCTION

Extrusion cooking of regular meat is difficult due to high moisture levels and presence of fat which cause product gushing out of the die in small granules or backflowing of the raw material from the extruder inlet (Megard et al., 1985). These problems are caused by lubrication of the extruder die and screw from fat and moisture resulting in product slippage or blockage of the die. Under these circumstances, any material that exits the die is of limited cohesion, crumbly and friable. These problems may be avoided by drying or defatting the meat before extrusion, and/or mixing with nonmeat binders and gelling agents, such as soybean proteins, starches, wheat flour, potato products and gums. Use of nonmeat ingredients in extruded meat products eliminates the above technical problems; improves binding and texture; and reduces their total fat, while increasing protein contents.

Products formed by extrusion of meat mixed with plant materials can be marketed as snacks, chunks or powders for soups or stews, and pasta products fortified with meat.

Several studies have indicated that, with various modifications, extrusion cooking of muscle tissues is possible and may be useful in upgrading product quality (Lawrie and Ledward, 1983; Areas and Lawrie, 1984; Kristensen et al., 1984; Alvarez et al., 1990). One economical source of animal protein is mechanically deboned poultry meat which has been used as a substrate for extrusion-cooked meat products (Megard et al., 1985; Alvarez et al., 1990). Studies in our laboratory have also examined the potential for development of extrusion-cooked meat products from combinations of poultry meat with various nonmeat ingredients of plant origin (Ba-Jaber, 1990). The objective of the present study was to determine the effects of soy protein isolate, kappa-carrageenan and oat fiber on extrusion-cooked mechanically deboned turkey meat.

MATERIALS AND METHODS

The raw materials used in the study were MDTM purchased from Longmont Foods (Longmont, CO), soy protein isolate (Mira-Pro. 121; Staley Manufacturing Co., Dekatur, IL), K-C gum (Hercules, Inc., Wilmington, DE) and OF (Mira; Canadian Harvest, Ontario, Canada). Used as variables, these ingredients and their levels were formulated into 18 (Table 1) out of a possible maximum of 54 treatments as a fractional factorial experimental design (Kempthorne, 1973). The extruder variables were fixed for all treatments as follows: screw speed at 100 rpm and extrusion temperature at 95°C. Before extrusion, the MDTM and the nonmeat ingredients were mixed in a KitchenAid mixer (model K45SS, Hobart Manufacturing Co., Troy, OH) at low speed for a total of 15 min. The mixed dough of each treatment was divided into two (200 g each) duplicate samples (A and B), which were stored at 4°C and extrusion-cooked on the same day.

Extrusion was performed in a Brabender plasticorder extruder (model PL-V500; C.W. Brabender Instruments, Inc., South Hackensack, NJ). The diameter of the barrel of the extruder was 19.00 mm with a 20:1 length-to-diameter ratio and eight 0.79 x 3.18 mm longitudinal grooves. A screw configuration of 1:1 compression ratio was used. The die plate used was 5.10 cm long with an 0.87 cm diameter opening. The two zones of the extruder were electrically heated and compressed air-cooled collars controlled by thermostats were used to control the temperature of the barrel. Two thermocouples were inserted through the barrel

Table 1. Fractional factorial experimental design for evaluation of extruded meat products formulated with mechanically deboned turkey meat (MDTM) and combination of soy protein isolate (SPI), kappa-carrageenan (K-C) and oat fiber (OF).

Treatment	SPI	K-C	OF
1	0	0	0
2	2	0	2
3	4	0	1
4	0	1	2
5	2	1	1
6	4	1	0
7	0	2	1
8	2	2	0
9	4	2	2
10	1	0	0
11	3	0	2
12	5	0	1
13	1	1	2
14	3	1	1
15	5	1	0
16	1	2	1
17	3	2	0
18	5	2	2

SPI: 0 = 16%; 1 = 18%; 2 = 20%; 3 = 22%; 4 = 24%; 5 = 26%. K-C: 0 = 0.3%; 1 = 0.6%; 2 = 0.9%. OF: 0 = 0%; 1 = 2%; 2 = 3%.

wall (Likimani, 1988) and indicated the temperature of the dough in the extruder.

Ground, moistened corn grits were choke-fed into the extruder until a steady state was achieved and between treatments. After the A samples were extruded, the duplicate B samples were extruded in the same manner. Each sample was collected from the die outlet in a plastic bag and stored for 1 day in a refrigerator (0-2°C) before evaluation. The extruded products were evaluated by a trained panel for cohesion (binding) and hardness (Clarke et al., 1988). The four-member sensory panel consisted of three males and one female individually trained to score the extruded products. For binding, they were trained to pull apart a 1-cm slice of frankfurter, which was given a score of 6, and a similar amount of ground turkey meat, which was given a binding score of 1, on the 6-point scale (Table 2). Hardness was evaluated on a 6-point scale against six foods assigned scores from 1 to 6, which served as anchor points (Szczesniak et al., 1963). The score of 1 corresponded with the hardness of cream cheese, while 6 was the hardness of peanuts (Table 2). The extruded samples were allowed to reach room temperature (1.5-2 hr), and portions of 20-30 g from each treatment were presented during each session to each panelist on a waxy sheet of paper. The anchor samples were place in a 6-muffin baking tin form next to the extruded samples with the evaluation sheet for reference.

RESULTS AND DISCUSSION

The results presented in Table 3 show that binding of 100% MDTM during extrusion cooking was affected significantly ($P < 0.05$) by the level of SPI and the level of K-C gum. The quadratic term of the SPI level, as well as the interaction between the levels of the gum and SPI also affected ($P < 0.05$) the binding of the extruded products. In addition, the quadratic term of the SPI level and the quadratic term of the OF level had significant effects ($P < 0.05$) on hardness. Figure 1 shows the effects of the levels of both SPI and K-C gum on the predicted binding of the MDTM extrusion-cooked products. At the low level (16%) of SPI tested, increasing the gum level from 0.3 to 0.9% caused a large increase in binding scores (about 3 points on the 6-point scale), but at higher levels of SPI (24%), an increase in the gum level from 0.3 to 0.9 increased binding only by one point, from 4.4 to 5.4. At a given level of K-C gum (from 0.3 to 0.6), increasing the level of SPI from 16 to 24% increased binding scores, but above 24% SPI, the binding scores remained constant or decreased slightly. This suggests that the gum improved binding when the amount of free moisture was higher (lower SPI levels). This was observed also during extrusion cooking, as less fluid separation and improved product texture. The most acceptable binding occurred at 22% SPI and 0.9% K-C (Figure 1). This score was 5.7 out of a maximum of 6.0 for frankfurters.

Table 2. Reference scale (anchor points) for sensory evaluation of extruded products.

Panel Scores	Hardness	Food source	Binding
1	Philadelphia cream cheese	Kraft, Inc., Glenview, IL	Ground turkey meat
2	Boiled egg whites		-----
3	Chicken franks	Bar-S Food Co., Phoenix, AZ	-----
4	Cheddar cheese	Kraft, Inc., Glenview, IL	-----
5	Ripe black olives (pitted)	Food Club, TopCo Assn. Inc., Skokie, IL	-----
6	Peanuts	Gold Crest, Inter-American Food, Inc., Cincinnati, OH	Chicken frankfurters

Table 3. Regression coefficients and statistical significance for binding and hardness scores of extrusion-cooked (100 rpm, 95°C) mechanically deboned turkey meat (MDTM) mixed with soy protein isolate (SPI, 16-26%), kappa-carrageenan (K-C, 0.3-0.9%) and oat fiber (OF, 0-3%).

Variables	Binding		Hardness	
	Regression Coefficients	Level of Significance	Regression Coefficients	Level of Significance
SPI level	1.196	0.0004	-----	N.S.
K-C level	1.137	0.0005	-----	N.S.
SPI x SPI	0.137	0.0107	0.055	0.0005
SPI x K-C	- 0.221	0.0184	-----	N.S.
OF x OF	------	N.S.	0.276	0.0007

N.S.: Not significant (P > 0.05). Constant 1.792 for binding and 1.135 for hardness.

Figure 2 shows the effect of SPI and OF levels on hardness. At a given level of OF (from 0 to 3%), by increasing the SPI level (from 16 to 26%), the hardness scores of the products increased; at a given level of SPI, by increasing the OF level, hardness also increased. The hardest product (a score of 5.6, which was between the hardness of olives and peanuts) occurred at 26% SPI and 3% OF. The softest product, with a score of 3.1 (similar to a frankfurter), occurred at 16% SPI and 0% OF. The hardness of the products with 22-24% SPI and 0-1% OF was still in the acceptable range (3-4 points). In general, adding OF caused easier feeding of the dough in the extruder, but it also resulted in an increase in the hardness of the product. Overall, the fiber level had no major or consistent effect on binding of the products (Tables 4 and 5).

CONCLUSION

This study showed that mixing MDTM with different levels of soy protein isolate (SPI) (16-26%) at an extrusion temperature of 95°C and a screw speed of 100 rpm allowed formation of restructured, extrusion-cooked products. The SPI level was the most significant (P < 0.05) factor affecting binding (cohesion). The level of the kappa-carrageenan (K-C) gum (0.3-0.9%) and the interaction between the levels of both SPI and K-C also caused a significant effect (P < 0.05) on binding. The level of oat fiber

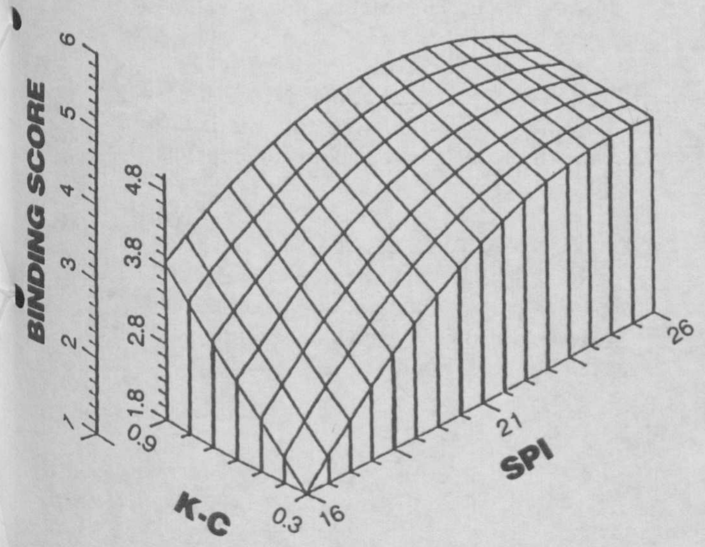

Figure 1. A response surface diagram for predicted binding scores of extruded mechanically deboned turkey meat with different levels of soy protein isolate (SPI) (16-26%), kappa-carrageenan gum (K-C gum) (0.3-0.9%) and oat fiber (0.0-0.3%) at the extrusion temperature of 95°C and screw speed of 100 rpm.

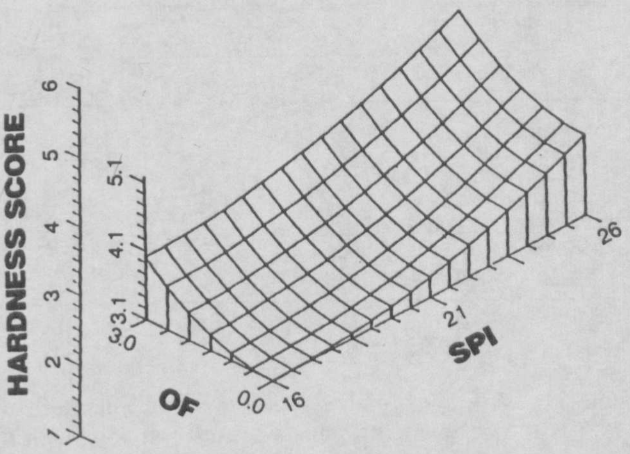

Figure 2. A response surface diagram for predicted hardness scores of extruded mechanically deboned turkey meat with different levels of soy protein isolate (SPI) (16-26%), kappa-carrageenan gum (0.3-0.9%) and oat fiber (OF) (0.0-3.0%) at the extrusion temperature of 95°C and screw speed of 100 rpm.

(OF) (0-3%) had no major effect on binding. Hardness of the products was affected ($P < 0.05$) by both the quadratic terms of SPI and K-C gum levels. Although the OF had no effect on binding, it did affect the texture by increasing hardness. The most acceptable products were formulated with 0.6-0.9% gum and with SPI levels not exceeding 24%.

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Table 4. Average binding scores of mechanically-deboned turkey meat product extruded at 95°C with different levels of soy protein isolate (SPI), kappa-carrageenan gum (0.3-0.9%) and oat fiber.

	Oat Fiber (%)		
SPI (%)	0	2	3
16	2.00	4.25	2.50
18	3.25	5.00	3.50
20	4.50	4.00	3.25
22	5.50	5.25	4.50
24	5.00	3.50	4.75
26	4.75	4.50	4.00

Table 5. Average binding scores of mechanically-deboned turkey meat products extruded at 95°C with different levels of soy protein isolate (16-26%), kappa-carrageenan gum (K-C) and oat fiber.

	Oat Fiber (%)		
K-C (%)	0	2	3
0.3	2.62	4.00	3.87
0.6	4.87	4.62	3.00
0.9	5.00	4.62	4.37

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