Study on the Effect of Proportion of Soya Flour and Corn Flour on Physicochemical Properties of Pork Nuggets

Sutarjo Surjoseputro, Thomas Indarto Putut Suseno and Dorkas Setiowati

Faculty of Agricultural Technology, Department of Food Technology and Nutrition
Widya Mandala Surabaya Catholic University, Surabaya (Indonesia)

ABSTRACT

Pork nuggets are one of restructured meats. Adding soy flour and corn flour as alternatives to replace wheat flour can produce pork nuggets. Soy protein (globulin) could form gel-protein matrix, besides -protein-starch gel matrix. The formation of matrix increased Water Holding Capacity (WHC) and formed cohesive texture of the products. Combination of 4% soy flour and 6% corn flour is the best treatment to produce acceptable pork nuggets.

Keywords: pork nuggets, soya flour, corn flour, texture profile

INTRODUCTION

Nugget is one of the popular restructured meat products. Nuggets could be made of chicken, beef or pork. Chicken nuggets are the most popular, while pork nuggets are least popular.

Ordinary nuggets are made of meat and wheat flour as one of the ingredients to get a cohesive texture; this is due to the starch content of wheat flour (*ca.* 67%) and protein (8-14%) and it helps in the formation of protein-starch gel matrix (Whistler *et al.* (1997).

Due to the dependency of wheat flour, the researchers would like to replace wheat flour to soy flour and corn flour; both flours are more available and affordable to be bought.

Soy flour contains approximately 50% protein, and could be used for increasing the Water Holding Capacity (WHC) and to reduce moisture lost during cooking. While corn flour contains approximately 61% starch and formed gel structure by heating and made cohesive structure of the nuggets

The objectives of this research are to study the influence of the proportion of soy flour and corn flour on physicochemical of pork nuggets; and to find the best treatment, which is accepted by the panelists.

MATERIALS AND METHODS

Materials

The pork used in these experiment was tenderloin, pre-rigor state (5 hours after slaugthering) and was purchased from the abattoir.

The ingredients consist of soy flour (derived from *Glycine soya* var. Wilis), corn flour (derived from *Zea mays* var. Hibrida), sodium tripolyphosphates (STPP) (Brataco Chemical), egg white, water, breadcrumbs, table salts, frying oil (Bimoli), and spices: garlic and white pepper).

Chemicals for analysis were prepared for protein analysis and fat analysis.

Experimental Design

The experiments were designed as a Randomized Group Design consists of single factor (T) with 7 levels: 10% wheat flour (T1); 10% soy

flour and 0% corn flour (T2); 8% soy flour and 2% corn flour (T3); 6% soy flour and 4% corn flour (T4); 4% soy flour and 6% corn flour (T5); 2% soy flour and 8% corn flour (T5); 0% soy flour and 10% corn flour.

The nuggets were made based on Todd *et al.* (1989) and Prinyawiwatkul, *et al.* (1997)'s formula. Each 1000 g (pork meat, soy flour and corn flour) were added 0.3% (w/w) STPP, 2% (w/w) table salts, 2.5% (w/w) garlic, 0.5% (w/w) white pepper, and 14% w/v water. The proportion of soy flour and corn flour both are according to the level of treatments as stated before.

Pork meat was minced through a mincer (JCW-46 Multi Use Mincer), and samples were prepared as stated in Figure 1.

Chemical and physical examination have been done for some parameters: moisture content (AOAC, 1984), protein content (Sudarmadji, 1997), fat content (Sudarmadji, 1997), WHC (Li *et al.*, 1993), Texture Profile Analysis (TPA) for hardness and cohesiveness (Universal Testing Instrument LLOYD/1000S), sensory evaluation by 69 panelist: taste and texture (Kartika, 1992).

All data were analyzed statistically using ANOVA. The difference of means between pairs was examined using Duncan's Multiple Range Test (DMRT). Level of significances was set for $P \leq 0.05$.

To determine the best treatments, Effectiveness Index (De Garmo, Sullivan and Canada, 1984) has been used.

RESULTS AND DISCUSSION

Protein content

Protein content of pork nuggets is between 17.14-22.77%. The lowest protein content was nugget with 10% corn flour (T7, while the highest was 10% soy flour (T2) both compared to nuggets with 10% wheat flour, which has 18.44% protein content.

There was significant different between treatments (*P d"*0.05). The protein contents of all treatments are stated in Table 1.

Protein content of the nuggets were influenced by protein content of all components such as pork meat, soy flour, corn flour, egg white, but soy flour and corn flour both contribute to the protein content of the nuggets. Soy flour gave the most contribution to protein content compare to corn nuggets. Soy flour contains 45.55% protein, while corn flour 11.65%.

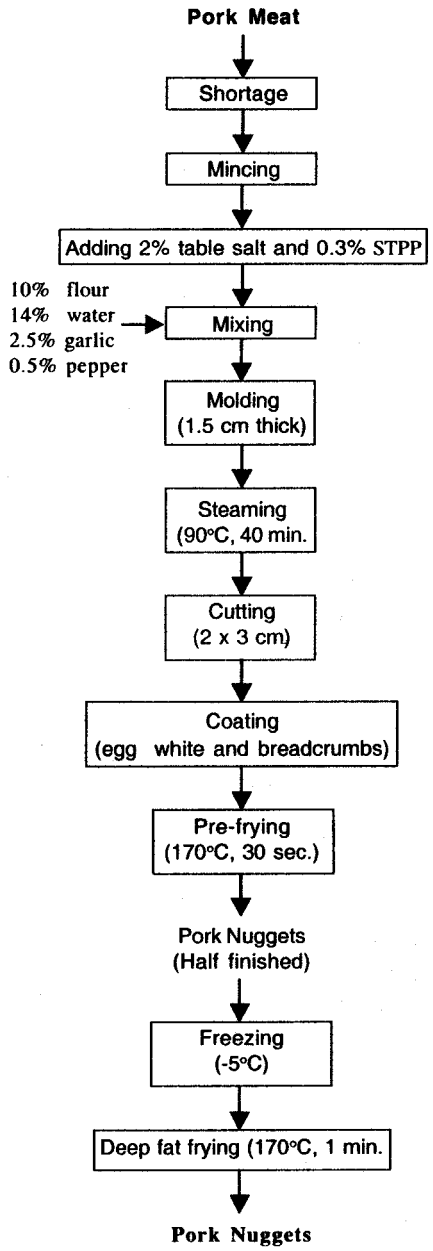

Figure 1. The Processing of Pork Nuggets (Modified from Prinyawiwatkul *et al.* (1997)

Table 1. Protein Content of Pork Nuggets

Treatments	Protein Content (% *wb*)
T7	17.14a
T6	18.44ab
T1	18.04ab
T5	18.90abc
T4	22.77bc
T3	20.67c
T2	20.02d

T1= 10% wheat flour; T2=10% soy flour; T3=8% soy flour and 2% corn flour; T4=6% soy flour and 4% corn flour; T5=4% soy flour and 6% corn flour; T6=2% soy flour and 8% corn flour; T7=10% corn flour
Means with different letters are significant different (*P* d" 0.05)

Moisture Content

Moisture content of pork nuggets are between 58.85-65.36%. Nuggets contain 10% soy flour (T2) has the lowest moisture content, while nuggets contain 10% wheat flour has the highest moisture content.

There were significantly different (*P* d" 0.05) among treatments to moisture content of the nuggets.

Moisture content of pork nuggets are stated in Table 2.

Table 2. Moisture Content of Pork Nuggets

Treatments	Protein Content (% *wb*)
T2	58.65a
T4	61.83b
T3	62.66b
T6	64.12b
T7	64.25b
T5	65.12b
T1	65.36b

T1= 10% wheat flour; T2=10% soy flour; T3=8% soy flour and 2% corn flour; T4=6% soy flour and 4% corn flour; T5=4% soy flour and 6% corn flour; T6=2% soy flour and 8% corn flour; T7=10% corn flour
Means with different letters are significant different (*P* d" 0.05)

Nuggets with 10% soy flour (T2) have the lowest moisture content compared to other treatments, even though it has the highest protein content. This is due to the influence of meat protein and soy protein to bind water through the hydrophilic groups and hydrogen bond. Interaction between starch and water in T2 was very low because soy four has low starch content, and the formation of protein-starch gel matrix was also low; the bound water was easily loosed during processing. The moisture content of other treatments was not only influenced by protein, but also by starch of corn or wheat starch in T1

Gliadin and glutenin of wheat four formed gluten in the nuggets of 10% wheat flour during mixing with water. Wheat flour which contains *ca.* 67% starch were involved in binding water through hydrophilic group. Interaction between proteins happened through disulphide groups. It was also happened on meat protein, gluten and starch gel. The formation of protein-starch gel matrix made the bound water in protein and starch were not easily loosed (Carballo *et al.*, 1995).

Water Holding Capacity

The values of WHC of pork nuggets are 3.01-4.05. Nugget of 10% soy flour (T2) has the lowest value, while nugget of 4% soy flour and 6% corn flour (T5) has the highest value both compared to nugget of 10% wheat flour (T1), which has 3.86. There were significant different among treatments (*P* d" 0.05).

Values of WHC of pork nuggets are stated in Table 3.

Table 3. WHC of Pork Nuggets

Treatments	WHC
T2	3.01a
T4	3.39ab
T3	3.50ab
T6	3.65ab
T7	3.71ab
T1	3.86b
T5	4.05b

T1= 10% wheat flour; T2=10% soy flour; T3=8% soy flour and 2% corn flour; T4=6% soy flour and 4% corn flour; T5=4% soy flour and 6% corn flour; T6=2% soy flour and 8% corn flour; T7=10% corn flour
Means with different letters are significant different (*P* d" 0.05)

Nuggets of 10% wheat flour (T1) and nuggets of 4% soy flour and 6% corn flour (T5) both have significant different WHC values to nuggets of 10%

soy flour (T2). Nuggets of T1 and T5 formed protein-starch gel matrix and involved in water retention, while nuggets of T2 has least for forming the gel matrix due to the lower starch content of soy flour. The values of WHC not only influenced by protein, but also by starch within corn flour like amylose and amylopectin).

Zayas (1997) stated that hydrophilic groups of protein can be bound with water through hydrogen bond; and during heating protein was denatured and the polypeptide structure opened. Interaction between proteins occurred through disulphide bond of the meat protein (actin and myosin) or of the soy protein (globulin) as well as between meat protein and soy protein. Nuggets of 10% wheat flour (T1) also formed gel protein matrix, due to interaction between disulphide groups of meat protein and of gluten. Fennema (1985) stated that interaction between protein and starch gel occurs through hydrogen bond. The formation of gel-protein matrix caused water retention; the tighter protein-starch bounded the more the ability of the product to retain the water.

Lipid content

Pork nuggets contain 5.72-10.22% lipid. Nuggets of 10% soy flour (T2) contain 10.22% lipid, while nuggets of 10% corn flour (T7) contain 5.72% lipid compared to nuggets of 10% wheat flour contains 6.04% lipid.

There were significant different ($P \leq 0.05$) among treatments. Table 4. shows the lipid content of pork nuggets.

Table 4. Lipid Content of Pork Nuggets

Treatments	Lipid content (%)
T7	5.72a
T1	6.04a
76	7.11a
T5	7.35ab
T4	8.27b
T3	8.73bc
T2	10.22c

T1= 10% wheat flour; T2=10% soy flour; T3=8% soy flour and 2% corn flour; T4=6% soy flour and 4% corn flour; T5=4% soy flour and 6% corn flour; T6=2% soy flour and 8% corn flour; T7=10% corn flour
Means with different letters are significant different (*P* d" 0.05)

There were no significant different between nuggets of 10% soy flour (T2) and nuggets of 8% soy flour and 2% corn flour (T3), but both treatments were significant different to other treatments. These differences were due to the different lipid content between soy flour and corn flour; soy flour has higher lipid content than corn flour, this means that soy flour gave great contribution to the lipid content of pork nuggets rather than corn flour. Soy flour contains 21.48% lipid, while corn flour has 2.24%, and wheat flour has 0.9%. The higher content of soy flour the higher lipid content of pork nuggets.

Pre-frying influenced the lipid content of the product, because frying oil has been absorb. Nuggets of T2 and T3 both have porous structure compared to nuggets of T6 and T7; and due to this structure the more frying oil would be absorbed.

Texture Profile Analysis

Hardness. The hardness of pork nuggets is between 62.30-82.54 N. The lowest value showed in nuggets with 10% corn flour (T7), while the highest showed in the nuggets with 10% soy flour (T2), both compared to nuggets with nuggets with 10% wheat flour (T1) that has 63.71 N. hardness. There were no significantly different ($P \leq 0.05$) among the treatments. Hardness value of pork nuggets is stated in Table 5

Table 5. Hardness value of Pork Nuggets

Treatments	Hardness (N)
T1	63.71
T2	82.84
T3	69.86
T4	62.89
T5	62.89
T6	67.99
T7	62.30

T1= 10% wheat flour; T2=10% soy flour; T3=8% soy flour and 2% corn flour; T4=6% soy flour and 4% corn flour; T5=4% soy flour and 6% corn flour; T6=2% soy flour and 8% corn flour; T7=10% corn flour
Means with different letters are significant different (*P* d" 0.05)

Myofibrillar proteins of pork meat determined hardness of pork nuggets. Myofibrillar protein was denatured due to heating, WHC value decreased. The decreasing of WHC influenced the hardness of pork nuggets. Hardness of pork nuggets also influenced by other components of soy flour and corn flour especially protein and starch because these two components are able to bind water.

Protein content has important role in water absorption. Praptiningsih *et al.* (2002) stated that the higher protein content the higher absorption of water, while Purnomo *et al.* (2000) stated that products which has high moisture content made the product softer and wet. Protein (actin, myosin, globulin and gluten) responsible for the formation of protein-gel matrix, and the texture of the nuggets become firmer.

Lipid content determined the hardness of the products. Pork nuggets of 10% soy flour (T2) have relatively high lipid content (10.22%), and nuggets became easier to be loaded and not resistant to pressure.

Starch from corn flour has the same characteristic with starch from wheat flour; it formed a short body paste and made the texture not too hard.

Cohesivenes. The range of cohesive-ness is between 0 to 1, the higher the value the more cohesive the products. The cohesiveness value of pork nuggets is between 0.31-0.66. The lowest value is nugget of 10% wheat flour (T1), while the highest is nuggets of 2% soy flour and 8% corn flour (T6). Cohesiveness of pork nuggets is stated in Table 6.

There were significant different (*P* d" 0.05) among treatments. Nuggets of 2% soy flour and 8% (T6) and nuggets of 10% wheat flour (T1) both are significant different. These differences are related to the starch gel formation. Corn starch gel is more viscous compared to wheat gel which has less viscosity (Whistler *et al.*, 1999). Due to these characteristics of gel formation, corn flour made the product more cohesive compared to nuggets of wheat flour.

Table 6. Cohesiveness value of Pork Nuggets

Treatments	Cohesiveness
T1	0.32a
T2	0.41ab
T3	0.52ab
T4	0.53ab
T5	0.55ab
T6	0.60b
T7	0.66b

T1= 10% wheat flour; T2=10% soy flour; T3=8% soy flour and 2% corn flour; T4=6% soy flour and 4% corn flour; T5=4% soy flour and 6% corn flour; T6=2% soy flour and 8% corn flour; T7=10% corn flour
Means with different letters are significant different (*P* d" 0.05)

Formation of protein-starch gel matrix contributes to the cohesiveness the products. The more tight the gel matrix, the more cohesive the product was. Nuggets of 10% soy flour (T7) have no significant different to nuggets of 10% wheat flour (T1) and to other treatments even though T2 has less interaction between protein and starch. T2 has high protein content (22.77%); more over soy flour has many disulphide groups that can be interact with meat protein to form gel protein matrix, and nuggets become cohesive.

Sensory evaluation

The panelist has done sensory evaluation to know which treatments are the most acceptable. Hedonic scale preference test has been done. The range of score is between 1 to 7; 1 means unacceptable; 4 means neutral; and 7 means high acceptable.

Taste. The range of acceptance of the products is between 3.81 to 4.87 (slightly unacceptable to neutral). There were significant different (*P* d" 0.05) among treatments. Level of acceptance of each treatment is stated in Table 7.

Spices and proportion of soy flour and corn flour influenced the taste of pork nuggets. Nuggets of 10% wheat flour (T1) has no significant different to other treatments, while the taste of nuggets of 4% soy flour and 6% corn flour (T5), and 6% soy flour and 4% corn flour (T4) are more acceptable compared to nuggets of 10% soy flour (T2).

Table 7. Taste Acceptability of Pork Nuggets

Treatments	Cohesiveness
T2	3.81a
T7	4.38ab
T1	4.41ab
T6	4.49ab
T3	4.55ab
T4	4.78b
T5	4.87b

T1= 10% wheat flour; T2=10% soy flour; T3=8% soy flour and 2% corn flour; T4=6% soy flour and 4% corn flour; T5=4% soy flour and 6% corn flour; T6=2% soy flour and 8% corn flour; T7=10% corn flour
Means with different letters are significant different (*P* d" 0.05)

Pork nuggets of T2 have strong bean flavor, while pork nuggets of combination of both flour are most acceptable than soy flour only.

Lipid content gave great influence to the acceptability of the products. The higher fat content the more unacceptable the products, as showed in T5 and T4.

Texture. The texture of pork nuggets is between 3.95 to 4.64 (slightly unacceptable to neutral). There were no significant different (*P d"* 0.05) among treatments. The range of acceptability of texture is stated in Table 8.

Table 8. Texture Acceptability of Pork Nuggets

Treatments	Cohesiveness
T1	4.33
T2	3.95
T3	4.53
T4	4.48
T5	4.61
T6	4.39
T7	4.64

T1=10% wheat flour; T2=10% soy flour; T3=8% soy flour and 2% corn flour; T4=6% soy flour and 4% corn flour; T5=4% soy flour and 6% corn flour; T6=2% soy flour and 8% corn flour; T7=10% corn flour
Means with different letters are significant different (*P* d" 0.05)

Effectiveness Index

The Effectiveness Index indicates the properly treatment of the best-fried pork nuggets. Each parameter has a rank according to consumer's expectation: taste (1.0); texture (1.0); hardness (0.9); cohesiveness (0.9); WHC (0.8); moisture content (0.8); protein (0.7); and lipid content (0.7).

Effectiveness Index of all treatments are stated in Table 9.

Table 9. Effectiveness Index of Pork Nuggets

Treatments	Effectiveness Index
T5	0.84
T7	0.75
T6	0.68
T4	0.66
T2	0.63
T3	0.62
T1	0.62

T1= 10% wheat flour; T2=10% soy flour; T3=8% soy flour and 2% corn flour; T4=6% soy flour and 4% corn flour; T5=4% soy flour and 6% corn flour; T6=2% soy flour and 8% corn flour; T7=10% corn flour
Means with different letters are significant different (*P* d" 0.05)

The highest effectiveness index is pork nuggets of 4% soy flour and 6% corn flour (T5).

CONCLUSIONS

The difference proportion between soy flour and corn flour has significant influence to protein content, lipid content, WHC and moisture content; and has no significant influence to hardness of the pork nuggets.

Based on sensory evaluation, pork nuggets of different proportion of flours effect the texture of the products, and this were slightly unacceptable, except the taste, and which was no different to pork nuggets of wheat flour only.

The best pork nuggets that can be produced are nuggets of 4% soy flour and 6% corn flour.

ACKNOWLEDGEMENT

The researchers would like to express their sincere gratitude to colleagues from Biochemistry Laboratory of Gadjah Mada University, Yogyakarta for their technical assistance.

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