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Possibility of Making Low-fat Sausages from Duck Meat with Addition of Rice Flour

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ABSTRACT : Low-fat sausages with or without 10% hydrated rice flour were made from duck, chicken and pork and their physical and sensory properties were compared. Results showed that moisture content did not differ significantly among the sausage batters. However, crude protein, crude fat and total ash content were significantly lower in the group with added rice flour compared with the no flour group. Crude protein and crude fat were the highest in pork sausages without rice flour ($p<0.05$). Adding 10% rice flour reduced total expressible fluid in all meat type sausages. Cooking loss was also decreased when 10% rice flour was used in making sausages from chicken and pork. However, no changes in cooking loss were found in duck meat by adding rice flour. Again, the highest cooking loss was in pork sausages without rice flour and lowest in chicken sausages with 10% rice flour. The pH of the meat from different animal species differs significantly, although no significant difference was found within meat types with or without rice flour. Lightness (L^*) increased, while redness (a^*) decreased with adding rice flour in all meat type sausages. Results showed that hardness was significantly reduced when 10% rice flour was added to pork, chicken and duck meat ($p<0.05$). This may be due to increased water retention of rice flour after cooking. Sensory evaluation indicated that the overall acceptability of pork and chicken sausages with or without rice flour was the same, but duck sausages without rice flour had the highest off-flavor score among the sausages. Addition of rice flour increased the overall acceptability of duck sausage to that of pork and chicken sausages. (**Key Words :** Meat Type, Low-fat Sausage, Rice Flour, Texture and Acceptability)

INTRODUCTION

As health problems such as obesity, heart disease and diabetes increase in many countries in the world, the food industry has come under mounting pressure to improve the nutritional quality of its products. Therefore, current health concerns have instigated numerous research projects on different types of foods and their constituents to determine whether there are some foods that should be increased, limited, or avoided in the diet to prevent such diseases. Particular attention has focused on the health problems associated with fat content in food and consumers are looking for no- or low-fat meat products. With excessive fat reduction, however the products desire bland and dry, and texture can be hard, resulting in less acceptable to consumers (Ahmed et al., 1990)

Carbohydrate-based fat substitutes use plant polysaccharides such as fibers and starches to retain moisture and to provide textural qualities that usually provided by fat (Wylie-Rosett, 2002). Again, the type of carbohydrate-based replacer used will have a profound influence on the final flavor profile of the product (Lucca and Tepper, 1994). Rice, *Oryza sativa L*., is the staple food for more than three billion people or over half the world's population, grown in at least 114 mostly developing countries, rice is the dominant crop in Asia (Cantrell and Hettel, 2004). The Asian continent, where 56 percent of humanity lives, produces and consumes around 92 percent of the world's rice (Papademetriou, 1999). Yang et al. (2009) reported that the total substitution of fat in duck sausages by rice flour produce a more acceptable product. Rice has shown promise for increasing yield and juice retention in meat (Huang et al., 2005), but limited research was done with rice compare to other cereals to produce meat product.

Although the meat industry are attempting to market of low-fat products, the beef, pork and poultry industries offer a wider variety of products. Sausages from pork are available in the market, and sausages from chicken were

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also tried by many researchers (Mielnik et al., 2002; Ahhmed et al., 2007). However, duck meat product does not get enough attention by the researcher. Duck is still very popular and in strong demand in many area of the world, especially in Asia.

Therefore, the objectives of this research were to evaluate how the addition of rice flour affects the quality properties of low fat sausages and to compare the effectiveness of incorporated rice flour on sausages prepared with different types of meats such as pork, chicken and duck.

MATERIALS AND METHODS

Manufacture of sausage

Pork leg, chicken and duck meat, and rice flour were purchased from a local market, stored at 4°C and used the following day. Different meat types were used at 3 days of post-mortem. All meats were trimmed off visible fat to reduce the fat content before grinding through a 3 mm plate. The average pH of the meat samples before making sausage batters were 5.716, 5.932 and 5.874 for pork, chicken and duck, respectively. To incorporate into sausage batter, the final moisture content of the meats was adjusted to 71%, and rice flour was added with water to have the final moisture content at 71%. These steps were taken to ensure that any differences observed for the added rice flour would not be biased by different moisture contents. Sausage batters were prepared in a cold room at 4°C (Table 1). With hydrated rice flour group, rice flour was added at a level of 10% (wt/wt) after adjusting the water at 71%. Control sausages were also prepared but without the addition of rice flour. For each batch of sausages, other ingredients were mixed using a mixer for 3 min at 4-6°C. After mixing, the mixtures were stuffed into synthetic cellulose casings (approximate diameter of 30 mm) using a stuffer (H15, TALSA, Zaragoza, Spain). The sausages were then held for 24 h at 4°C to allow for the ingredients to equilibrate. The sausage samples were then cooked for 30 min in a steam chamber (SAA10, Absury, Berlin, Germany) to the internal temperature of the sausages at 80°C.

Proximate composition

Proximate composition analysis of the sausage batters and rice flour was performed according to AOAC (AOAC, 2000). Moisture (950.46), protein (992.15), fat (985.15) and ash (920.153) of the sausage mixtures and rice powder were determined in triplicate.

pH measurement

To measure the pH, sausages samples (3 g) were homogenized using a poly-tron homogenizer (T25basic, IKA, Selanger, Malaysia) with distilled water (27 ml) and then measured pH using a pH-meter (MP230, Mettler Toledo, Toledo, OH). The pH meter was calibrated daily using standard buffers of pH 4.0 and 7.0 at 25°C.

Color analysis

The surface color (CIE *L**, *a**, *b**) of sausages samples were measured using a Minolta Chromameter (Minolta CR 301, Tokyo, Japan) standardized with a white plate (Y = 93.5, X = 0.3132, y = 0.3198). Five random reading were taken from each type of sausages. The measurements were averaged for each surface and the results were expressed as positive *L** (lightness), *a** (redness), *b** (yellowness).

Emulsion stability (total expressible fluid)

Emulsion stability, as total expressible fluid (TEF) was measured following to the procedure of Hughes et al. (1997). Twenty-five grams of the raw emulsion was placed in a centrifuge tube (3 replicates per formulation) and centrifuged for 1 min at 4,000×*g*. The samples were then heated in a water bath for 30 min at 70°C and then centrifuged for 3 min at 4,000×*g*. The pelleted samples were removed and weighed and the supernatants were poured into pre-weighed crucibles and dried overnight at

Table 1. Ingredient composition of sausage batter from different meat types and with/without rice flour

Ingredients	Pork*	Chicken*	Duck*	Pork +10% rice flour	Chicken +10% rice flour	Duck +10% rice flour
Lean meat	1,000	1,000	1,000	900	900	900
Rice flour[1]	-	-	-	100	100	100
Salt	15	15	15	15	15	15
Sodium tripolyphosphate	3.3	3.3	3.3	3.3	3.3	3.3
Spice/seasoning	3.7	3.7	3.7	3.7	3.7	3.7
Sodium erthorbate	0.37	0.37	0.37	0.37	0.37	0.37
Sodium nitrite	0.007	0.007	0.007	0.007	0.007	0.007
Corn syrup solids	14.8	14.8	14.8	14.8	14.8	14.8

* Control; without rice flour.
[1] Rice flour was hydrated to become 71% water after weight.

100°C. The volumes of TFE were calculated as follows:

TEF = (Weight of centrifuge tube and sample)
- (Weight of centrifuge tube and pellet)

% TEF = (TEF/sample weight)×100

Cooking loss

The loss due to cooking was determined for each treatment-replication combination. Weights of uncooked and cooked sausages were recorded (Boles and Swan, 1996). The cooking yield was calculated as the weight of the cooked sausage sample divided by the weight of the uncooked sample multiplied by 100.

Cooking loss (%) = ((uncooked weight-cooked weight) /uncooked weight)×100

Texture profile analysis (TPA)

Texture profile analysis was performed in an Instron Universal Testing Machine (Model 3343). Five sausage cores (diameter 2.5 cm, height 2.0 cm) per treatment were axially compressed to 70% of their original height. Force versus time curves were obtained with a 10 kg load cell applied at a crosshead speed of 100 mm/min. The textural attributes of hardness, cohesiveness, springiness, gumminess and chewiness were calculated from the curve (Bourne, 1978).

Moisture adsorption capacity (MAC)

Water absorption capacity were conducted using uncooked and cooked meat types, dehydrated rice flour and no hydrated rice flour following the procedure described by Yang et al. (2007). Prior to dehydration, the samples were prepared with or without heat treatment at 80°C for 30 min. All samples were then frozen at -70°C (Clean vac 8, Biotron, Gangneung, Korea) and freeze-dried over a 3 to 5 day period. Dried samples (approximately 1 g each) were put into polystyrene weighting dishes (2×2 inches, Fisher Scientific Co., Pittsburgh, PA) and further dehydrated in a vacuum desiccator over P_2O_5 for 5 to 7 days until constant weight was attained. The dehydrated samples were equilibrated at 25°C in sealed chambers over various saturated salt solutions with known relative vapor pressures (RVP): P_2O_5 (0), LiCl (0.11), KCH_3 (0.23), $MgCl_2$ (0.33), K_2CO_3 (0.43), Mg $(NO_3)_2$ (0.53), KI (0.69), $(NH_4)_2SO_4$ (0.81) and KNO_3 (0.93). Equilibrium moisture content (EMC; g H_2O/g of solid) was calculated from the weight gain after no further change in weight had occurred; triplicate samples from each treatment were measured.

Sensory evaluations

A sensory panel consisting of students, faculty, and staff of the Gyeongsang National University was used to evaluate sensory characteristics of the sausages. Recruitment, selection and training of panelists were performed according to sensory evaluation procedure (Carr et al., 1999), 10 panelists were screened from 13 potential panelists using basic taste identification test and trained with commercial sausage products for 2 weeks (three 30 min sessions per week) to the product characteristics planned to be evaluated. Cooked sausage samples from each treatment were placed in covered glass containers [Pyrex (Pyrex, Charleroi, PA) with plastic cover] and served warm (35°C) to each panelist one at a time. Panelists evaluated a total 6 samples (with or without rice flour) and the samples were transferred about 30 min before the sensory test started. The panelists evaluated each characteristic of the sample using a 9-point hedonic scale, where one (1) was "dislike extremely" and nine (9) was "like extremely." For sausages, the following score limit was used: color (1-3: pale, 4-6: normal, 7-9: dark), flavor (1-3: weak, 4-6: moderate, 7-9: strong), off-flavor (1-3: weak, 4-6: moderate, 7-9: strong), juiciness (1-3: small, 4-6: moderate, 7-9: large), tenderness (1-3: tough, 4-6: moderate, 7-9: tender) and overall acceptability (1-3: dislike, 4-6: moderate, 7-9: like).

Statistical analysis

The experiment was a complete randomized design with 3 replications in each batch. Data was analyzed by analysis of variance (ANOVA) using statistical analysis systems (SAS) and a Duncan's multiple range test was used to determine the significant difference among the means at 5% level of significance (SAS, 2002).

RESULTS AND DISCUSSION

Proximate analysis

The percentage moisture, protein, fat and ash of rice flour was 11.4, 7.6, 1.9 and 1.5, respectively (data not shown in Table). However, the proximate composition of sausage samples with or without rice flour is shown in Table 2. Moisture contents of the sausage batters ranged from 68.20 to 70.45%, and there was no significant difference among the sausage samples. This indicates that any differences in the physical properties and sensory ratings observed for rice flour low fat sausages would not be biased by different moisture contents for different meat types. Crude protein content in chicken and duck sausages with or without rice flour was significantly lower than their counter part with or without rice flour sausages from pork, respectively. In general, Crude protein content slightly reduced in all meat types with addition of rice flour. Fat

Table 2. Proximate composition (%) in low fat sausage batters with/without rice flour

Treatment	Moisture	Crude protein	Crude fat	Ash
Pork*	68.79±0.99	21.05±0.05^{A}	4.71±0.10^{A}	3.16±0.05^{A}
Chicken*	70.10±0.28	18.29±0.91^{BC}	3.64±0.38^{B}	3.11±0.09^{A}
Duck*	70.45±2.19	17.98±1.93^{BC}	3.78±0.34^{B}	3.18±0.20^{A}
Pork+10% rice flour	68.20±1.06	20.45±0.02^{AB}	3.90±0.32^{B}	2.57±0.07^{B}
Chicken+10% rice flour	69.70±1.03	16.94±0.64^{C}	2.39±0.11^{C}	2.74±0.21^{B}
Duck+10% rice flour	68.99±2.12	16.77±0.90^{C}	2.49±0.04^{C}	2.65±0.09^{B}

$^{A-D}$ Means with different superscripts within a column differ significantly (p<0.05).
* Control; without rice flour and rice flour was hydrated to become 71% water after weight.

contents in different sausages ranged from 2.39 to 4.71% and ash content ranged from 2.57 to 3.18. Fat and ash contents for pork, chicken and duck were significantly reduced by the addition of rice flour (p<0.05) in all meat type sausages. Sampaio et al. (2004) found reduced fat content in sausages using oat bran, carrageen, and cassava starch for production of beef frankfurters. However, this type of changes depends upon the composition of the replacer.

pH, emulsion activity (Total expressible fluid) and cooking loss

The pH was significantly different among the sausages made from different meat type, although no significant differences were found in sausages with or without rice flour. The sausage with 10% rice flour reduced TFE in all meat type sausages. Cooking loss also decreased in sausages with 10% rice flour made from chicken and pork, however, no changes were found in duck meat sausage by adding rice flour in cooking loss. The highest TFE and cooking loss were found in pork sausages without rice flour, amongst the meat types the highest reduction of TEF and cooking loss were found according to the addition of rice flour in pork. The lowest TEF and cooking loss were found in chicken meat sausages with rice flour. Also, the highest cooking loss was found in pork sausages without rice flour, while the chicken sausages with 10% rice flour had the lowest cooking loss (p<0.05). Emulsion activity indicates the ability of the emulsion to hold liquid at the time of performance of the emulsion and it is influenced by the fat content of the emulsion (Bhattacharyya et al., 2007). Higher fat content of sausages without rice flour had the higher emulsion activity compare to the sausages with rice flour. However, many researchers were reported that the decrease of fat content in sausage is accompanied by decrease of emulsion activity (Eilert et al., 1993; Paneras and Bloukas, 1994). Also, the highest fat content of pork sausages without rice flour had the highest emulsion activity.

CIE color values

Table 4 shows that the effect of rice flour on color of cooked low fat sausages. Lightness (*L**) decreased by adding rice flour, while redness (*a**) increased by adding rice flour (p<0.05). However, in yellowness (*b**) of cooked low fat sausage, duck sausage decreased by adding rice flour only. There were no significant differences in yellowness of pork and chicken sausage by adding rice flour (p>0.05). Pork sausage adding rice flour had the highest lightness among the sausages, but duck sausages with or without rice flour had lower lightness than other sausages with or without rice flour (p<0.05). However, duck sausages had higher redness than other sausages (p<0.05). Chicken sausages had the highest value of yellowness than other sausages regardless of adding rice flour. The color differences in different meat type sausages related to species characteristics, as Ali et al. (2007) found large differences in lightness, redness and yellowness between duck and chicken breast meat.

Table 3. pH, total expressible fluid (TEF) and cooking loss in low-fat sausage batters with/without rice flour

Treatment	pH	TEF (%)	Cooking loss (%)
Pork*	6.26±0.06^{C}	2.93±0.35^{A}	11.52±0.60^{A}
Chicken*	6.73±0.01^{A}	0.97±0.03^{D}	6.88±0.11^{C}
Duck*	6.57±0.00^{B}	2.53±0.05^{B}	8.38±0.93^{B}
Pork+10% rice flour	6.24±0.02^{C}	0.76±0.08^{D}	6.45±0.22^{C}
Chicken+10% rice flour	6.75±0.01^{A}	0.39±0.11^{E}	5.02±0.73^{D}
Duck+10% rice flour	6.62±0.04^{B}	1.55±0.18^{C}	7.36±0.36^{BC}

$^{A-E}$ Means with different superscripts within a column differ significantly (p<0.05).
* Control; without rice flour and rice flour was hydrated to become 71% water after weight.

Table 4. International commission on illumination color measurements of cooked low fat sausages with/without rice flour

Treatments	Lightness (L*)	Redness (a*)	Yellowness (b*)
Pork*	70.44±0.90^{C}	10.32±0.35^{C}	8.79±0.41^{C}
Chicken*	70.93±0.95^{BC}	7.87±0.31^{D}	10.28±0.26^{A}
Duck*	56.06±0.63^{E}	15.42±0.50^{A}	7.84±0.26^{D}
Pork+10% rice flour	72.97±0.68^{A}	6.98±0.20^{E}	9.15±0.32^{C}
Chicken+10% rice flour	71.42±0.76^{B}	5.30±0.22^{F}	10.07±0.42^{A}
Duck+10% rice flour	60.66±0.68^{D}	13.15±0.78^{B}	9.58±0.39^{B}

$^{A-E}$ Means with different superscripts within a column differ significantly (p<0.05).

* Control; without rice flour and rice flour was hydrated to become 71% water after weight.

Texture profile analysis

Table 5 shows the texture attributes of the sausages with different types of meat and with or without rice flour. Significant differences in some texture attributes were found in all meat type sausage samples (p<0.05). Among the sausages without rice flour, sausages from duck showed highest values in hardness, cohesiveness, gumminess, chewiness, while chicken had the lowest one. The textural properties of the sausages prepared with duck were most affected by addition of rice. Cohesiveness is a measure of the degree of difficulty in breaking down the internal structure of the sausages. Cohesiveness did not significantly differ while using rice flour with pork and chicken meat, however, cohesiveness significantly reduced in duck meat with adding rice flour. The springiness of the sausage samples did not differ significantly amongst the samples. Springiness represents the extent of recovery of sausage height and sometimes is referred to as "elasticity" (Sanderson, 1990). Gumminess and chewiness showed the same trend like hardness, and in both cases significantly lower value were found in rice flour group compare to without rice flour group. Similar type of results was found in pork sausages when using hydrated oatmeal and tofu by Yang et al. (2007). Hardness, cohesiveness, gumminess and chewiness significantly reduced with added hydrated oatmeal and tofu sausages than control. However, many researchers found the improvement of textural properties of meat product by reducing the hardness when different types of meat substitute like oat bran, soy protein, or starch were used (Ho et al., 1997; Prabhu and Sebranek, 1997; Desmond and Troy, 1998; Dawkins et al., 2001). Troutt et al. (1992) stated that a decrease in the hardness of sausage by the addition of texture-modifying ingredients may be associated with the water binding properties of the ingredient, such as soy protein, oat bran, and starch, i.e., the ingredient may help to absorb and retain moisture. This result might be similar to rice flour, as added rice flour group showed the lower hardness. However, limited research was done with rice flour as texture-modifying ingredients in meat product compare to others. However, results of our experiment revealed that most of the texture attributes were affected by adding rice flour in all meat types' sausages and the changes were drastic in duck.

Water absorption capacity

Figure 1 represents the moisture absorption capacity of pork, chicken and duck meat, and rice flour without cooking. As seen in Figure 1, at low a_w range (a_w <0.43) the equilibrium moisture content (EMC) was similar in all meat types, but found higher in rice flour. After this, all meat types' water activity increased very rapidly, while rice flour slowly. At highest a_w point (a_w = 0.93) the EMC was in the order of chicken meat, pork, duck meat and rice flour. This indicates that the moisture absorption capacity was higher in chicken meat and lower in duck meat at raw condition within the meat types, and rice flour had the lower water absorption capacity compare to different meat types. Figure 2 represents the moisture absorption capacity of pork, chicken meat, and duck meat and hydrated rice flour after cooking. At final a_w point the chicken meat has higher

Table 5. Textural attribute of cooked low fat sausages with/without rice flour

Treatment	Hardness (kg)	Cohesiveness	Springiness (mm)	Gumminess (kg)	Chewiness (kg*mm)
Pork*	0.41±0.04^{AB}	54.74±5.72^{A}	13.90±0.27	22.60±3.28^{AB}	313.69±43.22^{A}
Chicken*	0.34±0.08^{C}	51.99±3.38^{AB}	13.64±0.24	17.72±4.32^{C}	241.07±55.24^{B}
Duck*	0.45±0.06^{A}	56.30±3.23^{A}	12.29±2.92	25.19±4.23^{A}	319.29±102.47^{A}
Pork+10% rice flour	0.36±0.04^{BC}	54.48±3.50^{A}	13.77±0.09	19.70±2.84^{BC}	271.07±38.28^{AB}
Chicken+10% rice flour	0.27±0.02^{D}	44.11±2.28^{BC}	13.84±0.20	12.12±0.91^{D}	167.78±12.81^{C}
Duck+10% rice flour	0.22±0.09^{D}	42.69±15.44^{C}	12.45±3.59	11.25±5.01^{D}	159.21±76.62^{C}

$^{A-D}$ Means with different superscripts within a column differ significantly (p<0.05).

* Control; without rice flour and rice flour was hydrated to become 71% water after weight.

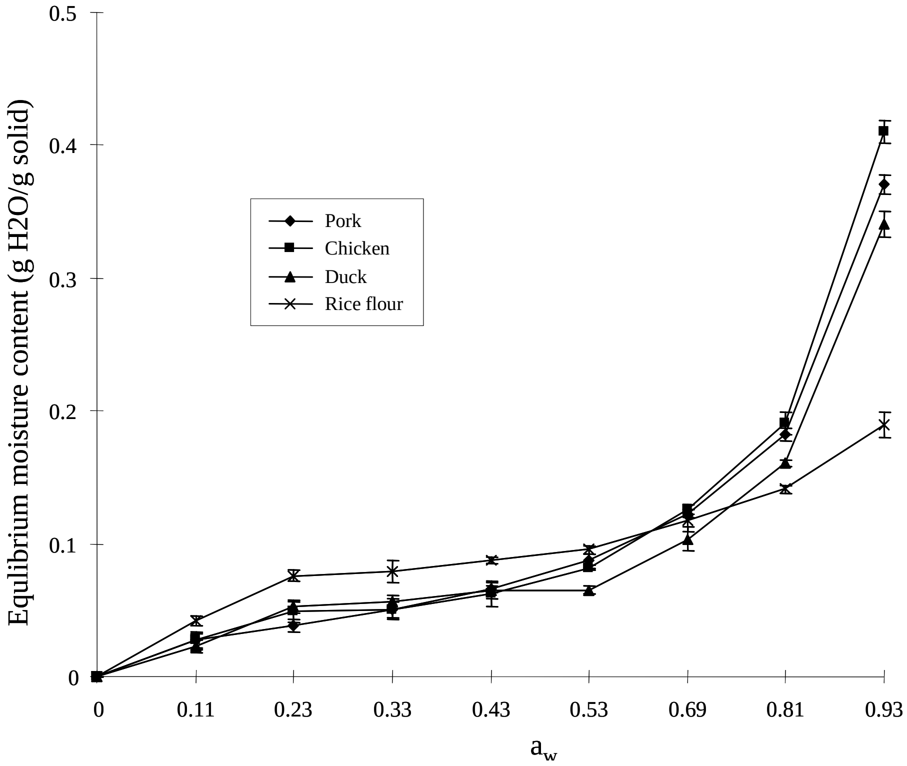

Figure 1. Moisture absorption capacity of pork, chicken and duck meat and rice flour without cooking.

equilibrium moisture content than duck meat and pork. However, rice flour is showing lower equilibrium moisture content than all meat types. If we compare Figure 1 and 2, it is evident that equilibrium moisture content decreased after cooking. Therefore, it was concluded that the lowering hardness in all meat type sausages with rice flour is related to hydrated rice flour content, as moisture absorption capacity did not decrease in rice flour after cooking. Increasing trends in water absorption capacity of flours as a result of heating have been observed in soybean flour (Wu

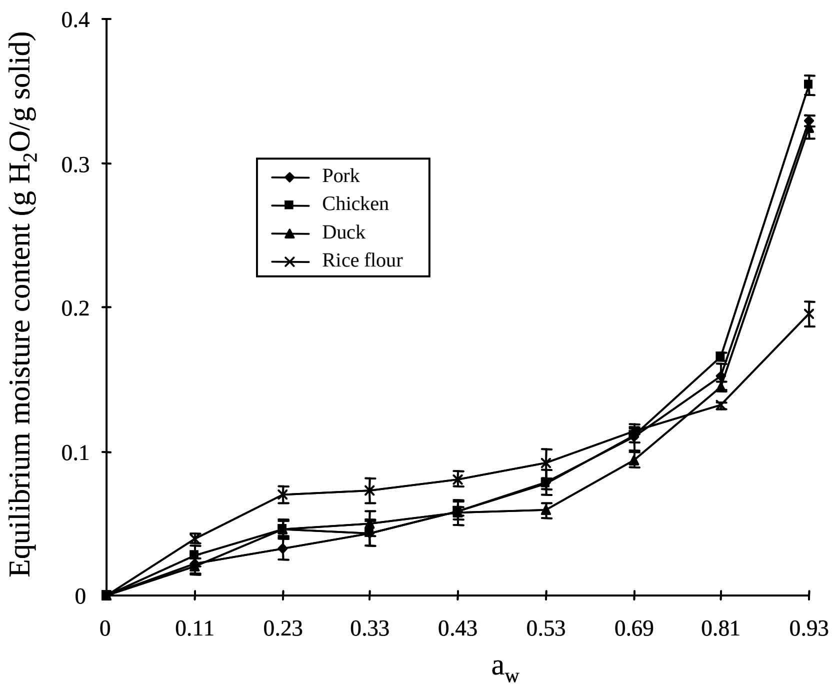

Figure 2. Moisture absorption capacity of pork, chicken and duck meat and hydrated rice flour after cooking at 80°C for 30 min.

Table 6. Sensory evaluation of cooked low fat sausages with/without rice flour

Treatment	Color	Flavor	Off-flavor	Juiciness	Tenderness	Overall acceptability
Pork*	5.31±0.43^{C}	3.41±1.90	2.97±2.16^{AB}	4.60±1.20^{AB}	5.17±0.75^{B}	6.43±1.40^{A}
Chicken*	3.23±0.61^{D}	4.27±1.94	3.27±1.61^{AB}	4.21±1.12^{AB}	5.90±0.83^{AB}	5.49±0.68^{AB}
Duck*	8.22±0.44^{A}	4.26±1.95	4.71±1.39^{A}	3.81±1.51^{AB}	5.14±0.99^{B}	4.39±1.52^{B}
Pork+10% rice flour	4.93±0.82^{C}	4.01±1.73	2.16±1.83^{B}	5.66±1.88^{A}	6.10±0.95^{A}	6.54±1.44^{A}
Chicken+10% rice flour	2.79±1.01^{D}	3.61±1.84	2.86±1.64^{AB}	3.51±1.30^{B}	6.31±0.30^{A}	5.27±0.43^{AB}
Duck+10% rice flour	6.74±0.57^{B}	3.39±1.80	3.89±1.81^{AB}	4.89±1.99^{AB}	6.73±0.77^{A}	6.09±1.39^{A}

$^{A-D}$ Means with different superscripts within a column differ significantly ($p<0.05$).
* Control; without rice flour and rice flour was hydrated to become 71% water after weight.

and Inglett, 1974), peanut flour (Rahma and Mostafa, 1988), moth bean flour (Pawar and Ingle, 1988) and velvet bean flour by 11% (Ahenkora et al., 1999). This behavior could be explained by more water binding sites becoming available to dissociated protein subunits upon heating than for undenatured protein (Pawar and Ingle, 1988).

Sensory evaluation

Table 6 showed sensory evaluations of the sausages with different types of meat and with or without rice flour. There were significant differences in color, flavor, off-flavor, juiciness, tenderness and overall acceptability among sausages prepared with different types of meat with or without rice flour ($p<0.05$). Tenderness value was increased by addition of rice flour. Although duck meat sausages without rice flour had a good color attribute from sensory evaluation, the off-flavor of duck meat sausages without rice flour reduced its overall acceptability. However, when duck meat sausages prepared with addition of rice flour, the overall acceptability increased.

Several studies have shown that the addition of starch, polysaccharides, or non-meat proteins in ground muscle-based food products can lead to an acceptable product. Our results also agreed with the previous reports that acceptability did not changed by using the rice flour in sausages. Yang et al. (2007) found significantly better sensory scores when using oatmeal at 10, 15 and 25% for preparing the sausages compare to same level of used tofu and control. Yang et al. (2009) also found that the addition of rice flour significantly increased overall acceptability score. Lean-pork sausage with 1.5% carageenan had better sensory scores for juiciness and tenderness when compared to either low-fat or full-fat controls (Huffman et al., 1992). Chang and Carpenter (1997) found that the addition of water and oat bran were significant on product hardness and juiciness.

CONCLUSION

Fat and protein contents of low fat sausages were reduced by adding rice flour. Addition of rice flour also reduced the TFE in all meat type sausages and cooking loss in pork and chicken sausages. Cooking loss was lower in duck meat sausages with rice flour than in sausages without rice flour. Lightness increased and redness decreased in all meat type sausages after adding rice flour. Moreover, rice flour in different meat type sausages reduced the hardness, and the highest reduction of hardness was found in duck meat sausages. Sensory evaluation indicates that the overall acceptability for pork and chicken sausages were same as the sausages with or without rice flour, however duck sausages without rice flour were worst quality among the sausages because of the highest off-flavor score. However, rice flour increased the overall acceptability of duck sausage. Therefore, this study demonstrates that duck meat can be used to make the preferred low fat sausages which is replaced with 10% hydrated rice flour.

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