



Physicochemical and Sensory Properties of Restructured Jerky with Four Additives

Su Kyung Ku, Jong Dae Park, Nam Hyuck Lee, Hee Ju Kim¹, and Young Boong Kim*

Korea Food Research Institute, Sungnam 463-746, Korea

¹*Meat Bank, Incheon 404-300, Korea*

Abstract

This study was carried out to evaluate the effect on properties of restructured jerky by the addition volume of additives. The treatments were divided into glutinous rice flour, potato starch, soybean and acorn powder. Moisture content, water activity (a_w), thiobarbituric acid reactive substances (TBARS), color, yield and sensory evaluation were performed. The moisture contents of four types of restructured jerkies were in the range of 8.92-12.47%, and were lower than that of the control (17.92%). Water activity tended to decrease with increasing addition of all treatments. The restructured jerkies containing glutinous rice flour, potato starch, soybean and acorn powder had lower TBARS than the control. The drying yield tended to increase with increasing amount of additives. In the sensory evaluation results, the highest overall acceptability was found in jerky containing glutinous rice flour, potato starch, and acorn powder when the addition was 9%, while that for soybean powder was determined to be 5%. These results suggest that 9% additions of glutinous rice flour, potato starch or acorn, or 5% soybean powder are optimal addition volumes for the preparation of restructured jerkies.

Key words: restructured jerky, excipient, water activity, TBARS, property

Introduction

Consumers prefer to high quality, variety, and convenience food, dine-out accounts for a huge part of the food consumption in Korea these days (Park *et al.*, 2005). In case of meat consumption especially, even though the consumption of fresh meat is most common based upon the ‘grilling’ cultural background, the demand of healthy meat products such as low fat and functional meat products tends to be increased, recently. In beef, sirloin, tenderloin, and striploin with high fat content are favored while the low fat parts of beef such as shank, rump, and round are not much preferred (Lee and Jin, 2004). Given the fact, there has been an issue regarding unbalance in the beef consumption. In addition to the unbalanced consumption, the beef trimming meat that is produced processing for meat cuts are partially utilized in the production of hamburgers, Tteokgalbi (beef pan cakes), as well as sausages whereas have not been applied for the higher-value added meat products yet.

Fats have considerable effects on the binding, rheological, structural and sensory properties including flavor, taste, juiciness, and texture of meat products (Hughes *et al.*, 1997; Pearson and Gillett, 1999). Excessive fat intake may cause multiple health problems due to the elevation of cholesterol in body, many consumers demand healthier meat products that are low in fat, cholesterol, nitrites and calories in general. However, reduction of fat in finely ground meat products is extremely challenging and poses difficulties in terms of appearance, flavor, and texture (Li and Yeh, 2003). In order to achieve a desirable texture, various texture modifying ingredients and binders are used such as starch, dietary fibers and polydextrose (Skrede, 1989; Trout *et al.*, 1992). Starch is an important biopolymer in food and has been used as a fat replacer in meat products. Starch has been recognized as a filler in surimi and used to increase the firmness of products and enhance the gel strength (Kim and Lee, 1987; Verrez-Bagnis *et al.*, 1993; Wu *et al.*, 1985). Lots of studies have performed to reduce fat content in meat products and fat replacements that possess the similar physicochemical properties with fat, safflower seed addition (Park *et al.*, 2012), potato powder addition (Ali *et al.*, 2011), and hazelnut or olive oil in fermented sausages (Kayaardi and Gok, 2004; Yildiz-Turp and Serdaroglu, 2008).

*Corresponding author: Young Boong Kim, Processing Technology Research Group, Convergence Technology Research Division, Korea Food Research Institute, Sungnam 463-746, Korea. Tel: 82-31-780-9180, Fax: 82-31-780-9076, E-mail: kybaaa@kfri.re.kr

In general, refrigerating, freezing, heating, salting, drying, and smoking process are employed in order to increase the storage of meat and meat products. Among those storage methods, drying lowers water activity (a_w) by controlling the moisture content and relative humidity of meat thereby inhibiting the growth of microorganisms. Different microorganisms would grow since water activity varies depending on the products. For instance, snacks have been widely consumed due to the secure of food safety based upon their low water activity (less than 0.70) (Calicioglu *et al.*, 2003). Beef jerky is the most common dried meat product, which is high protein and low fat is produced by seasoning and drying (Lee and Park, 2004). Beef, lamb, pork, and venison are mainly used to produce dried meat (Carr *et al.*, 1997; Choi and An, 1996; Munoz *et al.*, 2012; Lee and Kang, 2001; Park *et al.*, 2009; Van Laak, 1994). Several studies have been carried out with regards to restructured jerky such as the study regarding relationship between drying conditions and quality (Mgbemere *et al.*, 2011; Oh, 2004), the study of physico-chemical and microbiological characteristics (Yang *et al.*, 2009), and the study regarding the effects of water activity (Im, 1992). Whereas there is very little information available on the use of additives as fat replacer for restructured jerky and the resulting of the products in Korea.

Therefore, the objective of this study was to investigate the effects of glutinous rice flour, potato starch, soybean and acorn powder addition on the quality properties of restructured jerky produced by utilizing the trimming meats that were generated during the process.

Materials and Methods

Materials and experimental treatments

Trimming meat that was used during process was utilized in the production of restructured jerky. The specification of the trimming meat was standardized based on the

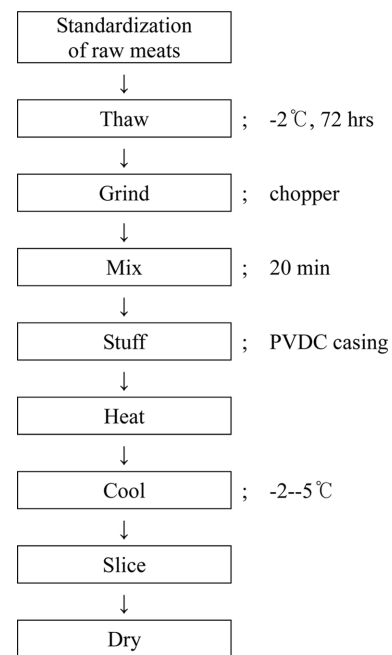


Fig. 1. Basic manufacturing procedure of restructured jerky by amount of glutinous rice flour, potato starch, soybean and acorn powder.

content of general composition (moisture 70.87%, protein 18.42%, fat 10.07% and ash 0.99%). The basic formulation and process was presented in Table 1 and Fig. 1. The trimming meat was ground by a chopper with 5 mm plate (MEW-727, Mado Co., Germany) and then mixed using a vacuum mixer at 6 bar, 53 rpm (Mixer-600, Hyupjin Co., Korea) for 20 min following the ratio of formulation. The restructured jerky consisted of the following components (in terms of w/w): raw meats (66.78%), back fat (19.94%), additives (glutinous rice flour, potato starch, soybean and acorn powder (5, 9, 13 and 15%), water (9.97%) and others (curing ingredients, salt, frank seasoning, charcoal barbecue taste base, 3.32%). The restructured jerky mixture was stuffed into polyvinylidene chloride casing Φ 9 mm in diameter. After heating at 85°C and cooling at -2 to -5°C, each preparation was sliced in to 2 mm widths.

Table 1. Basic formulation of restructured jerky by amount of glutinous rice flour, potato starch, soybean and acorn powder

Ingredients (%)	Treatments				
	Control	5	9	13	15
Raw meats	66.78	66.78	66.78	66.78	66.78
Back fat	19.94	14.94	10.94	6.94	4.94
Additives ¹⁾	-	5	9	13	15
Water	9.97	9.97	9.97	9.97	9.97
Curing ingredients etc. ²⁾	3.32	3.32	3.32	3.32	3.32
Total	100	100	100	100	100

¹⁾Glutinous rice flour (T1), potato starch (T2), soybean (T3) and acorn powder (T4).

²⁾Curing ingredients, salt, frank seasoning, charcoal barbecue taste base.

Samples were dried in 50°C for 7 hr. The treatments were divided with glutinous rice flour (T1), potato starch (T2), soybean (T3) and acorn powder (T4) (Table 1).

Moisture content and water activity (a_w)

The moisture content was measured according to method AOAC (1990). Restructured jerky samples were homogenized prior to measurement of water activity (a_w). Approximately 2 g ground samples were put into a holding cup, and then determined by water activity meter (Lab-Master-aw CH 8853 Lachen, Novasina, Switzerland).

Thiobarbituric acid reactive substances (TBARS)

TBARS was measured using the TBA extraction method by Witte *et al.* (1970). A 10 g sample was homogenized with 25 mL trichloroacetic acid (TCA) of 20% (in 2 M phosphoric acid) and centrifuged at 14,000 rpm for 2 min. Distilled water, 50 mL, was then added to the homogenized sample and stirred for 1 min. After a filtration, 5 mM TBA was added to 5 mL of the filtered solution. The mixture was incubated for 15 hrs and then absorbance was measured at 530 nm. TBARS were calculated by the following equation.

$$\text{TBARS (mg malondialdehyde(MA)/kg sample)} = \text{Absorbance} \times 5.2$$

Color

Color of samples was measured utilizing a color difference meter (Model CR-300. Minolta Co, Japan) with 9 replicates and expressed as CIE L (Lightness), a (redness), and b (yellowness) with the standard plate of 97.12 (L), -0.13 (a), and 2.14 (b).

Drying yield

Sample weight before and after the drying at 50°C for 7 hr was measured and then the drying yield was calculated using the following equation.

$$\text{Drying yield (\%)} = 100 - \left\{ \frac{\text{sample weight before drying (g)} - \text{sample weight after drying (g)}}{\text{sample weight before drying (g)}} \times 100 \right\}$$

Sensory evaluation

Sensory evaluation of samples is carried out against appearance, flavor, taste, texture acceptability, and overall acceptability with a scale of 9 points by 20 panels. Scores obtained by panels indicates appearance, flavor, and taste (1 = extremely bad, 9 = extremely good), texture (crispi-

ness: 1 = extremely soggy, 9 = extremely crispy), texture acceptability and overall acceptability (1 = dislike extremely, 9 = like extremely).

Statistical analysis

Statistical analysis was performed using SAS (Statistical Analysis System, 2002) program and the results were expressed as mean and standard deviation. Significance tests were done using ANOVA and Duncan's multiple range tests ($p < 0.05$) were carried out as post-hoc test.

Results and Discussion

Moisture content, water activity (a_w) and drying yield

The moisture content, water activity and drying yield of restructured jerky with amounts of glutinous rice flour (T1), potato starch (T2), soybean (T3) and acorn powder (T4) were showed in Table 2. The moisture content was in the range of 8.92-10.73%, 7.90-9.81%, 7.18-9.73%, and 11.50-12.47% with glutinous rice flour, potato starch, soybean, and acorn powder, respectively. The moisture content was decreased by glutinous rice flour and potato starch were added, whereas was increased as soybean powder and acorn powder were added ($p < 0.05$). The moisture content of the control was significantly higher (17.92%) compared to those of other treatments ($p < 0.05$) and was similar to the commercially available beef jerky (approximately 20% of moisture content) produced in Korea (Jung *et al.*, 1994). Among the restructured jerky with soybean powder, 13% soybean powder added had the lowest moisture content, whereas addition of 5% in acorn powder was the lowest. The moisture content of additives used in this study was determined and the results showed glutinous rice flour 10.86±0.32%, potato starch 12.08±0.31%, soybean powder 0.93±0.07%, and acorn powder 16.43±0.36%, respectively. Acorn powder treatment contained the highest moisture content among other treatments. Since the restructured jerky with acorn powder added was also showed the highest moisture content, the moisture content of the additive seemed to influence on the moisture content of the restructured jerky with the additive.

Water activity is the classification standard for dried food. Generally the water activity of semi-dried food should be ranged 0.60-0.90 so that are considered to be relatively safe food against microorganisms. It was reported that drying temperature, water activity, and addition of preservatives including salt and sugar were af-

Table 2. Moisture contents, water activity (a_w) and drying yield of restructured jerky by amount of glutinous rice flour, potato starch, soybean and acorn powder

	Treatments (%)	Glutinous rice flour	Potato starch	Soybean powder	Acorn powder
Moisture content (%)	Control	17.92±0.29 ^a	17.92±0.29 ^a	17.92±0.29 ^a	17.92±0.29 ^a
	5	10.73±0.63 ^{Ab}	9.81±1.24 ^{Ab}	7.51±0.04 ^{Bd}	11.50±0.15 ^{Ac}
	9	9.53±0.11 ^{Bbc}	9.29±0.08 ^{Bbc}	7.18±0.00 ^{Cd}	11.74±0.29 ^{Abc}
	13	9.25±0.70 ^{Bbc}	8.80±0.25 ^{Bbc}	9.73±0.28 ^{Bb}	12.47±0.21 ^{Ab}
	15	8.92±0.92 ^{Bc}	7.90±0.09 ^{Bc}	8.13±0.06 ^{Bc}	12.08±0.00 ^{Ab}
Water activity (a_w)	Control	0.76±0.01 ^a	0.76±0.01 ^a	0.76±0.01 ^a	0.76±0.01 ^a
	5	0.62±0.00 ^{Bb}	0.63±0.01 ^{Bb}	0.50±0.01 ^{Cd}	0.66±0.00 ^{Ad}
	9	0.59±0.01 ^{Bc}	0.55±0.03 ^{Bc}	0.49±0.00 ^{Cd}	0.68±0.00 ^{Ac}
	13	0.55±0.00 ^{Cd}	0.54±0.01 ^{Ccd}	0.63±0.00 ^{Bb}	0.70±0.00 ^{Ab}
	15	0.54±0.00 ^{BCd}	0.50±0.00 ^{Cd}	0.58±0.03 ^{Bc}	0.69±0.00 ^{Abc}
Drying yield (%)	Control	44.02±0.06 ^c	44.02±0.06 ^d	44.02±0.06 ^c	44.02±0.06 ^b
	5	38.54±0.17 ^{De}	43.28±0.45 ^{Ae}	39.56±0.14 ^{Cd}	41.15±0.08 ^{Bc}
	9	42.11±0.03 ^{Dd}	46.81±0.08 ^{Ab}	43.27±0.15 ^{Cc}	44.97±0.62 ^{Bb}
	13	46.92±0.12 ^{Ba}	46.14±0.15 ^{Cc}	46.11±0.16 ^{Cb}	48.26±0.45 ^{Aa}
	15	46.28±0.09 ^{Cb}	52.15±0.30 ^{Aa}	47.42±0.59 ^{Bca}	48.59±0.55 ^{Ba}

^{A-D}Means with different superscripts in the same row represent significant difference at $p < 0.05$.

^{a-d}Means with different superscripts in the same column represent significant difference at $p < 0.05$.

Table 3. TBARS of restructured jerky by amount of glutinous rice flour, potato starch, soybean and acorn powder

	Treatments (%)	Glutinous rice flour	Potato starch	Soybean powder	Acorn powder
TBA (mg MA/kg sample)	Control	0.53±0.01 ^a	0.53±0.01 ^a	0.53±0.01 ^a	0.53±0.01 ^a
	5	0.22±0.01 ^{Cc}	0.14±0.01 ^{Dc}	0.31±0.01 ^{Bb}	0.57±0.04 ^{Aa}
	9	0.26±0.01 ^{Bc}	0.18±0.02 ^{Bc}	0.42±0.05 ^{Aab}	0.43±0.04 ^{Ab}
	13	0.38±0.01 ^{Cb}	0.49±0.02 ^{Ab}	0.44±0.02 ^{Bab}	0.37±0.01 ^{Cb}
	15	0.52±0.04 ^{Aa}	0.47±0.04 ^{Ab}	0.48±0.11 ^{Aa}	0.21±0.03 ^{Bc}

^{A-D}Means with different superscripts in the same row represent significant difference at $p < 0.05$.

^{a-c}Means with different superscripts in the same column represent significant difference at $p < 0.05$.

affected on the storage (Ledward, 1981). Studies also suggested that browning reaction tended to be accelerated at high water activity and microorganisms was easily grown when water activity was greater than 0.85. Furthermore, it was showed that water activity should be lowered less than 0.7 in order to extention during storage (Banwart, 1979; Im, 1992). In this study, the water activity was ranged of 0.54-0.62, 0.50-0.63, 0.49-0.63, and 0.66-0.70 according to the amount of glutinous rice flour, potato starch, soybean, and acorn powder added, respectively. The water activity showed a decreasing tend to as more glutinous rice flour (T1), potato starch (T2) and soybean powder (T3) were added while was increased as the amount of acorn powder (T4) addition was increased. This would be associated with the increased moisture content when the amount of acorn powder addition was increased. This is similar to the result by Allen *et al.* (2007) indicating that there was a positive correlation between water activity and moisture content. In addition, Lee and Kang (2001) reported that the water activity of dried ostrich meat was decreased with the decrease of

moisture content. Meanwhile, when comparing between the water activity of the samples at the same amount of additives, the water activity with acorn powder was significantly higher compared to other additives like the result of moisture content. When adding 5% and 9% of additives, the soybean powder added samples showed the lowest water activity while the low water activity was exhibited in restructured jerky with glutinous rice flour and potato starch for 13% and 15% additives, but no significant differences.

In the results of the drying yield, it tended to be increased as the amount of glutinous rice flour, potato starch, soybean, and acorn powder in the samples was increased. The drying yield of the samples added with higher than 13% of glutinous rice flour (T1) and soybean powder (T3) were relatively higher than that of the control (44.02%). All the samples added with potato starch (T2) and acorn powder (T4) except for the 5% showed significantly higher drying yield compared to that of the control ($p < 0.05$). In the comparison of the samples at the same amount of additives, significantly high drying yield was

showed in the samples added with 5%, 9%, and 15% of potato starch while the sample with 13% of acorn powder addition tended to result in high.

In general, starch and flour improve cohesiveness as well as water holding capacity in food. Several studies reported that application of such additives in meat products allowed being able to form the gels with enhanced water holding capacity and emulsifying capacity thereby increasing the yield of meat products (Chin *et al.*, 1999; Shewry and Tatham, 2000). This study was also showed that the yield was increased by increasing the amount of glutinous rice flour, potato starch, soybean and acorn powder. Thus given the results, glutinous rice flour, potato starch, soybean, and acorn powder were showed to be the effective additives increase the yield in the production of restructured jerky. Berry (1997) reported that the yield of meat products was increased with the addition of pea fibers and tapioca starch, which was also in similar to this study.

Thiobarbituric acid reactive substances (TBARS)

In high fat meat products, thiobarbituric acid reactive substances (TBARS), an indicator to predict the degree of lipid oxidation, is measured by determining the amount of malonaldehyde which is produced in the auto-oxidation during storage (Raharjo and Brewer, 2007). Park *et al.* (2012) reported that dry-cured meat was tend to oxidative rancidity by oxidants while curing. The result of TBARS against restructured jerky which was added the amount of treatments was showed in Table 3. As a result, TBARS in the restructured jerky added with amount of glutinous rice flour (T1), potato starch (T2), soybean (T3) and acorn powder (T4) were ranged of 0.22-0.52, 0.14-0.47, 0.31-0.48, and 0.21-0.57 mg MA/kg sample, respectively. Increased TBARS was showed in the glutinous rice flour, potato starch, and soybean powder added restructured jerky samples. Compared to the control, TBARS for the potato starch added samples were significantly lower ($p < 0.05$). In this study, significant difference was not showed between the control and the samples added with more than 15% and 9% of rice flour (T1) and soybean powder (T3), respectively. On the other hand, TBARS in the acorn powder (T4) sample was reduced when the concentration was increased so was different from the samples with the other additives. Comparing to the restructured jerky samples at the same amount of the additives, 5% of acorn powder addition resulted in significantly higher TBARS than that of the other samples with 5% additives while TBARS of 15% acorn powder added sam-

ples were significantly low. Moreover, TBARS tended to be low when T1 and T2 were added by 5% and 9% while TBARS in the 15% of glutinous rice flour (T1), potato starch (T2) and soybean (T3) added samples was significantly high. This result was in accordance with that of Torres *et al.* (1994) and Han *et al.* (2007) who reported that TBARS increased with the decreased of a_w in dry-cured pork sausage and pork jerky. Whereas in this study, the decreased TBARS by the increase of acorn powder addition was showed to be caused by the antioxidant effects of acorns. Many researchers reported that acorns, which consisted of approximately 70% of starch, were involved in astriction and contained a lot of tannin (6-9%), gallic acid, digallic acid, and gallotannin thereby having antioxidant effects (Kwon *et al.*, 2002; Lee *et al.*, 1992; Lopes *et al.*, 1999). Therefore, the result suggested that the addition of glutinous rice flour, potato starch, soybean, and acorn powder could potentially be as fat replacements.

Color

Color was evaluated for restructured jerky depending on amount of glutinous rice flour (T1), potato starch (T2), soybean (T3) and acorn powder (T4). The results were showed in Fig. 2. Lightness (L) of treatments samples resulted in the ranges of 44.40-51.29 (T1), 47.80-51.50 (T2), 37.58-41.74 (T3), and 34.22-36.38 (T4), respectively. The L value of samples added with glutinous rice flour and potato starch showed higher than control (38.69). However, restructured jerky with soybean powder samples was significantly different from the 5% and acorn powder significantly the highest was found in the control ($p < 0.05$). Jin and Ban (2008) reported that tannin was responsible for the darkness of acorn powder. They also reported that significantly low lightness was showed in the acorn added sausages, which was similar to this study. Redness (a) of the samples added with treatments were in the range of 11.41-19.55 (T1), 9.51-17.88 (T2), 6.15-9.09 (T3), and 4.94-9.95 (T4), respectively, indicating significant reduction in the redness with the increase of the amount of addition regarding all additives. The soybean and acorn powder fortified samples showed the highest redness in the control ($p < 0.05$). Yellowness (b) was ranged of 7.62-9.99, 7.18-11.89, 4.32-4.59, and 2.63-3.22 for glutinous rice flour, potato starch, soybean, and acorn powder added samples, respectively. It was showed that the b value in the glutinous rice flour and potato starch added restructured jerkies tended to be higher compared to that of the control (3.96) while it was relatively lower in the acorn powder samples than that of the con-

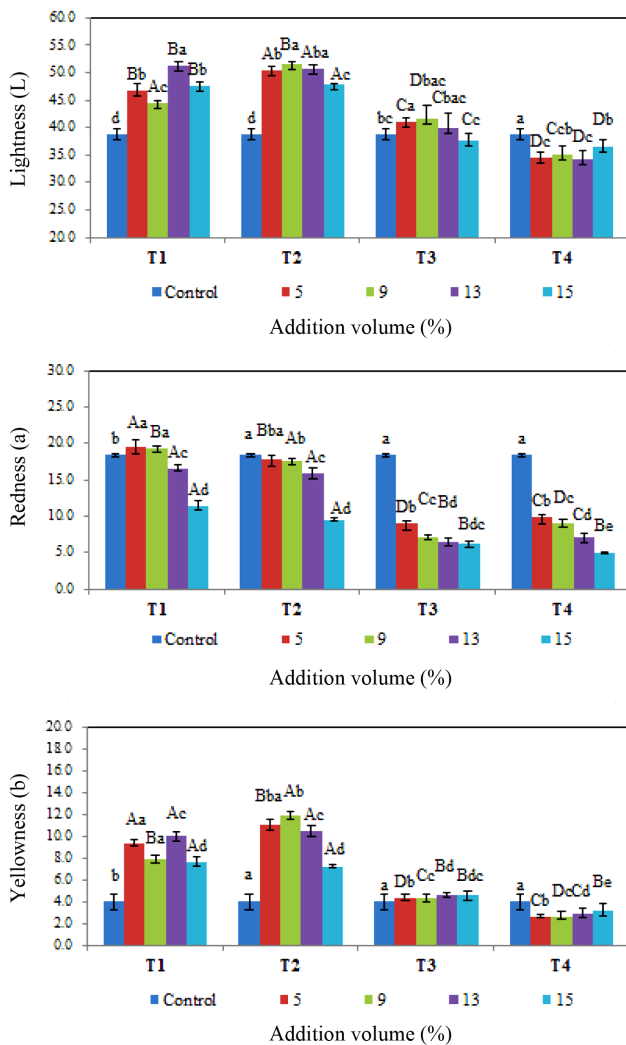


Fig. 2. Color value of reconstructed jerky by amount of glutinous rice flour (T1), potato starch (T2), soybean (T3) and acorn powder (T4). ^{A-D}Different letters indicate significant differences among treatments within the same addition volume ($p < 0.05$). ^{a-c}Different letters indicate significant differences among addition volume within the same treatment ($p < 0.05$).

control ($p < 0.05$). However, in the samples added with soybean powder, it was no significant differences showed between the control and samples added with all kinds of additives. Comparing to the reconstructed jerkies added with same amount, it was showed that L value and a value tended to be high in the samples added with T1 and T2 whereas low in the T3 and T4 added samples. In contrast, it was reported that b value was low in the samples with soybean and acorn powder. Numerous studies have reported that the color of reconstructed jerky is typically dependent on light, oxygen, temperature, and process and packaging conditions and the color based upon drying duration is influenced by the moisture content of the products (Acton

and Dick, 1977; Cava *et al.*, 2009; Chasco *et al.*, 1996; García-Esteban *et al.*, 2004; Mancini and Hunt, 2005; Rubio *et al.*, 2008).

Sensory evaluation

Sensory evaluation results of the restructured jerky added with 4 treatments were presented in Table 4. The samples added with 5% of glutinous rice flour were scored high in appearance and the score was tended to be decreased as the amount of glutinous rice flour in the samples was increased. Moreover, the 15% of glutinous rice flour added ones resulted in the lowest overall acceptability. High scores in flavor and taste were showed in the samples at 5% and 9% of additives, respectively. Crispiness was increased as greater amount of glutinous rice flour was present in the samples. The highest acceptability was showed in the samples with 9% additives, but indicating no significant differences compared to that of the other samples. Overall, the restructured jerky added with 9% additives was showed the highest preference while there was no significant difference compared to that of the ones fortified with 5% additives. Considering the TBARS and drying yield in the case, the samples with 9% additives seemed to be more suitable due to relatively lower TBARS and drying yield. Similar to the glutinous rice flour, the samples tended to be crispier when more potato starch was added to the samples. The potato starch samples with 9% additives resulted in the highest scores in flavor, taste, and texture acceptability, however representing that significant differences were not found compared to the other samples. Based upon the price of potato starch and back fat, when fewer carriers are present in the samples, it might be more economical but result in low yield. Therefore, it would be more suitable to add 9% of additives which were scored generally high in flavor, taste, and texture acceptability. For the soybean powder added samples, the 5% added samples showed the highest scores in appearance and the appearance was significantly less liked as the amount of additives was increased except for the 9% samples. As like lightness was decreased with the addition of soybean powder, visible darkness might be attributed lowering the appearance preference. There were no significant differences showed in favor and taste based upon the kinds of additives. In case of soybean powder, differences in flavor and taste would not be identified up to 15% samples because of its own strong flavor and taste. With the increase of soybean powder content, the samples tended to be crispier but significant differences were not showed in the acceptability. Unlike res-

Table 4. Sensory evaluation of restructured jerky by amount of glutinous rice flour, potato starch, soybean and acorn powder

	Treatments (%)	Glutinous rice flour	Potato starch	Soybean powder	Acorn powder
Appearance ¹⁾	Control	6.86±1.21 ^{ba}	6.86±1.21 ^a	6.86±1.21 ^a	6.86±1.21 ^a
	5	7.33±0.87 ^{Aa}	6.67±0.87 ^{ABa}	7.00±1.31 ^{Aa}	5.88±1.25 ^{Bab}
	9	7.22±1.09 ^{Aa}	6.56±0.73 ^{ABa}	5.88±1.13 ^{BCab}	5.13±1.36 ^{Cbc}
	13	6.33±0.87 ^{Ab}	5.44±0.88 ^{ABb}	5.25±0.71 ^{BCbc}	4.38±1.19 ^{Cc}
	15	5.98±0.78 ^{Ab}	4.89±1.05 ^{ABb}	4.63±1.19 ^{Bc}	4.50±1.41 ^{Bbc}
Flavor	Control	6.57±1.13 ^{ba}	6.57±1.13	6.57±1.13	6.57±1.13
	5	7.22±0.67 ^{Aa}	7.33±1.00 ^A	5.63±0.92 ^B	6.00±0.53 ^B
	9	6.78±0.67 ^{ABab}	7.56±0.73 ^A	5.88±0.83 ^B	6.63±1.19 ^{AB}
	13	6.67±0.50 ^{Ab}	6.56±1.13 ^{AB}	5.63±1.06 ^B	6.13±0.99 ^{AB}
	15	6.33±0.87 ^{Ab}	6.33±1.00	5.38±1.51	4.50±1.41
Taste	Control	7.00±1.15 ^{ba}	7.00±1.15 ^{ab}	7.00±1.15 ^a	7.00±1.15 ^a
	5	6.78±0.97 ^{ABab}	7.78±0.67 ^{Aa}	6.00±1.31 ^{Bab}	6.00±1.31 ^{Bab}
	9	7.22±1.09 ^{Aa}	7.89±0.78 ^{Aa}	5.75±1.16 ^{Bab}	6.88±1.13 ^{Aa}
	13	6.33±0.71 ^{ABab}	6.67±1.32 ^{Ab}	5.25±1.28 ^{Bb}	6.00±1.31 ^{ABab}
	15	6.00±1.41 ^{ABb}	6.11±1.05 ^b	5.50±1.51 ^b	6.00±1.31 ^b
Texture (degree)	Control	2.71±1.25 ^c	2.71±1.25 ^c	2.71±1.25 ^c	2.71±1.25 ^c
	5	5.33±1.58 ^{BCb}	5.89±0.93 ^{Bb}	7.63±1.06 ^{Aa}	4.50±1.51 ^{Cb}
	9	6.00±1.00 ^{ABab}	6.22±0.83 ^{ABab}	7.00±1.20 ^{ABab}	5.13±1.36 ^{Bab}
	13	6.67±0.87 ^{Aa}	6.78±1.20 ^{ABab}	5.75±1.28 ^{ABb}	5.50±0.93 ^{Bab}
	15	7.00±1.41 ^{ABa}	7.11±0.78 ^{Aa}	6.25±1.39 ^{ABb}	4.75±1.16 ^{Ba}
Texture (acceptability)	Control	4.57±0.98 ^b	4.57±0.98 ^b	4.57±0.98 ^b	4.57±0.98
	5	6.00±1.66 ^a	6.22±0.97 ^a	6.75±1.28 ^a	5.38±1.51
	9	6.22±1.30 ^a	6.22±0.97 ^a	6.13±1.13 ^a	5.63±1.19
	13	5.78±0.97 ^{ab}	6.00±1.41 ^a	5.50±1.51 ^{ab}	5.50±1.41
	15	6.00±1.22 ^a	6.22±0.97 ^a	5.38±1.19 ^{ab}	5.88±0.83
Overall Acceptability	Control	5.71±0.95 ^{AB}	5.71±0.95 ^b	5.71±0.95 ^{ab}	5.71±0.95 ^{ab}
	5	6.33±1.22 ^{AB}	7.00±0.87 ^{Aa}	6.50±1.20 ^{ABa}	5.63±1.19 ^{Bab}
	9	6.56±1.01	7.11±1.05 ^{Aa}	5.75±1.16 ^{Bab}	6.38±1.19 ^{ABa}
	13	5.78±0.97 ^A	6.44±0.88 ^{ABab}	5.38±1.60 ^{Bab}	6.13±1.25 ^{ABab}
	15	6.11±0.93	5.89±0.78 ^{ABb}	4.75±1.16 ^{Cb}	4.88±1.36 ^{BCb}

^{A-C}Means with different superscripts in the same row represent significant difference at $p < 0.05$.

^{a-c}Means with different superscripts in the same column represent significant difference at $p < 0.05$.

¹⁾appearance, flavor, and taste (1 = extremely bad, 9 = extremely good), texture (crispiness: 1 = extremely soggy, 9 = extremely crispy), texture acceptability and overall acceptability (1 = dislike extremely, 9 = like extremely).

restructured jerky added with glutinous rice flour and potato starch, the crispiness was increased as the amount of soybean powder was decreased because the content of soybean powder, 20.9% (refer to food composition table), would affect the properties of the restructured jerky. The 5% added samples showed the highest overall acceptability without significant differences compared to the samples added with 9% and 13%. In addition to the highest overall acceptability, it was also scored high in appearance, flavor, taste, and texture so that added with 5% of soybean powder is recommended. The appearance of the samples added with acorn powder was generally less preferred than that of the ones with glutinous rice flour, potato starch, and soybean powder. Significant differences were not showed in the flavor by the content of acorn powder. Only the samples with 15% of acorn powder were

showed significantly low in taste ($p < 0.05$). Although crispiness was increased as the amount of acorn powder was increased like the other additives, there was no significant difference showed in acceptability among the additives. Since significant differences were not showed in texture acceptability but in flavor and taste for the samples with 9% addition of the additive was suggested to be the optimal addition volume.

Conclusion

The results of this study showed that the restructured jerky added with glutinous rice flour, potato starch, soybean, and acorn powder was effective to lower moisture content, water activity, as well as TBARS and dry yield. According to sensory evaluations, the highest overall ac-

ceptability was showed when 9% of glutinous rice flour, potato starch, and acorn powder was added to the products samples. However, for soybean powder 5% addition was also present highest overall acceptability. Therefore, it is suggested that the addition of glutinous rice flour, potato starch, soybean, and acorn powder could potentially be as fat replacements, providing the consumer with a new type of jerky.

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