



Original Article

Quality characteristics of raw and canned goat meat in water, brine, oil and Thai curry during storage

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Abstract

The quality characteristics of three groups of goat meat obtained from one year and three years old Anglonubian crossed native, and culled Saanen crossed native were investigated. Significant differences in fat, ash and total collagen content, were observed among groups of goat meat ($P < 0.05$). The meat from younger goat was lighter in color and more tender ($P < 0.05$). Chemical composition and physical properties of raw goat meat from 3 years Anglonubian crossed native and 7 years Saanen crossed native were similar. The quality characteristics of canned goat meat in water, brine, oil, and Thai curry (massaman) made from those three groups of goat meat were determined during storage. The heat penetration at 118°C to F_0 values 7.5 of all goat meat products was also studied. During storage at room temperature, canned goat meat in water and oil had a non-significant increase in drained weight while significant results were obtained from goat meat in brine and curry ($P < 0.05$). Three years Anglonubian crossed native and 7 years Saanen crossed native goat meat had more hardness and chewiness than one year Anglonubian crossed native when processed in water and brine media. Media types had more influence on texture of canned goat meat rather than the groups of meat. Canned goat meat was markedly reduced in hardness and chewiness when processed in massaman curry and oil media. Storage time had a significant effect on texture of canned goat meat. Twenty days after storage, a dramatic reduction of hardness and chewiness was observed ($P < 0.05$). L^* , a^* and b^* value of all canned goat meat did not change ($P > 0.05$) during storage. The influence of groups of goat meat on TBARS value was significantly observed ($P < 0.05$) when processed in water and brine. Massaman curry could reduce the change in TBARS value of canned goat meat during storage. The results based on texture, color and lipid oxidation suggested that there were no significant differences between the groups of goat meat from 3 years Anglonubian crossed native and 7 years Saanen crossed native for being processed in canned goat meat curry products.

Keywords: goat meat, quality characteristics, chemical composition, colour, texture, TBARS, canning, and curry

1. Introduction

Goat are widely distributed around the world (Webb *et al.*, 2005). Goat meat is popular with the greatest production and consumption in Asia and Africa (Kannan *et al.*, 2001). The consumption of goat meat is mainly increased by ethnic consumers. Webb *et al.* (2005) stated that popularity and usage of goat meat varies within and between communi-

ties according to a host of criteria. Therefore, the consumer preference of goat meat is almost universal depending on cultural traditions and social and economic conditions. In Thailand, the production of goat meat steadily has increased in recent years especially in the Southern part (Department of Livestock, 2006), due to the increment of consumer demand. In addition, the government has a policy to increase goat meat production to provide a sufficient supply for the halal food industry in the future. There is an opportunity to process and sell goat meat to the Middle East and niche markets in Asia, where goat meat is traditionally consumed,

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or to the Western countries with ethnic communities that traditionally consume goat meat, but currently receive no or inadequate supplies of that product (Glimp, 1995; Swan *et al.*, 1998). Although the marketing potential for goat meat is increasing, information on the characteristics of goat meat and its products for the goat meat industry in Thailand is still limited and needs more study.

Normally, goat meat can be supplied from farming goat meat or farmed goats culled for age. In southern part of Thailand, Anglonubian x Thai native goat is generally produced for goat meat and consumed at age of nearly one year or maximum at 2-3 years old. Saanen x Thai native goat is primarily produced for dairy products and will be culled at an age of over 7 years. It is important to examine the potential uses of goat meat from different supplied sources for producing added-value product. Information on quality characteristics of goat meat from different sources and its characteristics after canning in different types of media is scarce. The objective of the present study was to determine quality characteristics of raw goat meat obtained from one year and three years Anglonubian x native and culled Saanen x native goats and its quality after canning in water, brine, oil and Thai curry (massaman) within 50 days of storage.

2. Materials and Methods

2.1 Goat meat and preparation

Goat meat used in this study was divided in three groups obtained from each of 4 female goats: Anglonubian x Thai native aged 1 year (live weights 15.3 ± 1.5 kg), aged 3 years (live weights 25.6 ± 2.5 kg) and Saanen x Thai native aged 7 years (live weights 26.8 ± 3.1 kg). All goats were supplied by the Small Ruminant Research and Development Center, Faculty of Natural resources, Prince of Songkla University. Meat from leg-chump on position was dissected from the carcass after 24 h chilling at 4°C, removed skin and trimmed off obvious fat and connective tissue. All meat samples were cut to size 3 x 4 x 1.5 cm before analysis and process.

2.2 Canned goat meat preparation and storage condition

The pieces of each group of samples were cooked in boiling water for 10 min and drained before packing in can size 307x113 (100 ± 2 g of precooked meat per can). Each group of canned samples was filled with four different types of media; distilled water, 5% NaCl brine, 80% soya oil and massaman curry (20% commercial curry paste in water) for 80 g per can. All samples were exhausted in a 3 m exhaust-ion box for 5 min and hermetically sealed with a seamer. The samples were processed at 118°C for Fo value of 7.5 in still steam retort. The time for heat penetration of each sample to achieve the target Fo was measured by thermocouple copper/constantan type T connected to Ellab potential meter. All canned goat meat samples were stored in shelf at

room temperature (28-30°C) for 50 days. Samples were randomly taken every 10 days during storage for quality changes evaluation.

2.3 Chemical analyses of raw meat

The pH of raw goat meat samples were determined 24 h postmortem by homogenizing the samples with distilled water at a ratio of 1:5 (wt/vol.). The homogenate was subjected to pH measurement using a combined glass electrode pH meter.

Moisture was determined by oven method (AOAC, 1999); protein was by Kjeldahl method (AOAC, 1999). Fat content was determined by the soxhlet apparatus method (AOAC, 1999); and ash was determined with a furnace at 600°C (AOAC, 1999).

Total collagen content was determined after acid hydrolysis as described by Palka (1999). Finely ground meat (500 mg) was hydrolysed with 25 ml of 6 M HCL at 110°C for 24 h. The hydrolysate was clarified with activated carbon, filtered, neutralized with 10 M and 1 M NaOH, and diluted with distilled water to a final volume of 250 ml. The hydroxyproline content in the hydrolysate was determined by the procedure of Bergman and Loxley (1963) and converted to collagen content using the factor 7.25. The collagen content was expressed as milligrams of collagen per gram of meat sample.

Soluble collagen was extracted according to the method of Liu *et al.* (1996). Samples (2 g) were homogenized with 8 ml of 25% Ringer's solution. The homogenates were heated for 70 min at 77°C and centrifuged for 30 min at 2,300 x g at 4°C. The extraction was repeated twice. Supernatants obtained were combined. The sediments and supernatants were hydrolyzed with 6 M HCL at 110°C for 24 h. The collagen content of the sediments and supernatants were determined as described previously. The amount of heat-soluble collagen was expressed as a percentage of the total collagen (collagen content in sediment plus that in the supernatant).

Myoglobin content in raw meat samples was measured by spectrophotometric method (Geileskey *et al.*, 1998). The concentration of myoglobin was calculated according to the equation mentioned by Eder (1996): total myoglobin (mmol/l) = $0.132A_{525}$. The myoglobin content was expressed as mg per g of meat sample using molecular weight = 16,110 g/mol (Gomez-Basauri and Regenstein, 1992).

2.4 Physical analyses of raw meat

The colour of goat meat samples was determined using a Hunterlab colorimeter (HunterLab ColorFlex, Reston, VA.) and reported in the complete International Commission on Illumination (CIE) system colour profile of lightness (L^*), redness (a^*), and yellowness (b^*).

Meat samples were cut to the size of 1.0 x 2.0 x 0.5

cm for shear analysis using Texture Analyzer equipped with a Warner-Bratzler shear apparatus. The operating parameters consisted of a cross head speed of 2 mm/s and a 25 kg load cell. The shear force was measured perpendicular to the axis of muscle fibers. The peak of the shear force profile was regarded as the shear force value.

Cooking loss of goat meat samples was examined by a similar method to that of Wattanachant *et al.* (2004). The strips of meat samples size 3 x 4 x 1.5 cm were put in a tightly sealed plastic bag and cooked in water bath at 80°C for 10 min. After being cooked, the samples were cooled in cold water at 10°C. The samples were removed from the container, blotted with filter paper, and weighed to determine the cooking loss as a percentage of initial weight.

2.5 Determination of canned goat meat quality during storage

The weight of meat samples was measured after draining off the media for 2 min and regarded as the drained weight of canned product.

The CIE colour profile of meat samples after draining off the media was determined using a Hunterlab colorimeter.

Canned goat meat samples were cut to size 2x2x1.5 cm for texture profile analysis (TPA). Textural properties (hardness, springiness and chewiness) of canned goat meat samples were measured using a Texture Analyzer equipped with 05-mm-diameter XT2i P/5 stainless steel cylindrical probe. TPA parameters were measured at room temperature, according to the following testing procedure: crosshead speed 2 mm/sec, final strain 50%, time interval between first and second stroke 1 s. Hardness, springiness and chewiness were calculated from the resultant force deformation curves.

The thiobarbituric acid reactive substances (TBARS)

were determined as described by Buege and Aust (1978). Samples (0.5 g) were mixed with 2.5 ml of 0.375% thiobarbituric acid, 15% trichloroacetic acid and 0.25% HCl stock solution in glass test tube. The mixture was heated for 10 min in a boiling water bath (95-100°C) to develop a pink color. The test tube was cooled with tap water and then centrifuged at 5500 rpm for 25 min. Absorbance of the supernatant was measured at 532 nm using a spectrophotometer. The TBARS were calculated from a standard curve of malondialdehyde (MDA) and expressed as mg MDA/kg sample.

2.6 Statistical analysis

Data were subjected to analysis of variance followed by Duncan's multiple range test using the SPSS 10.0 computer program.

3. Results and Discussion

3.1 Quality characteristics of raw goat meat

Table 1 shows quality characteristics of goat meat obtained from one year, three years Anglonubian x Native goat (1-y Ag x Nt and 3-y Ag x Nt, respectively) and seven years Saanen x Native goat (7-y Sn x Nt). The ultimate pH of all goat meat were in the range of 6.5-6.6 ($P \geq 0.05$) which was higher than that of South African indigenous goats (5.88-6.03) (Simela *et al.*, 2004a,b). High ultimate pH values in meat can indicate stressed animals during pre-slaughter handling. Moisture and protein content of goat meat were not significantly different among groups ($P \geq 0.05$). The moisture content ranged between 76.6% and 78.6% and protein content between 17.5 and 20.4% were in agreement with

Table 1. Quality characteristics of raw goat meat obtained from different ages and breeds goat

Parameter	Anglonubian x Thai native		Saanen x Thai native
	1 year	3 years	7 years
pH	6.57±0.05 ^a	6.68±0.08 ^a	6.62±0.28 ^a
Moisture (%)	76.61±1.15 ^a	77.73±0.25 ^a	78.63±0.08 ^a
Protein (%)	20.39±1.06 ^a	19.02±2.41 ^a	17.47±0.80 ^a
Fat (%)	1.14±0.12 ^a	2.01±0.94 ^{ab}	3.16±0.45 ^b
Ash (%)	0.45±0.18 ^a	1.16±0.65 ^b	0.57±0.05 ^a
Total collagen (mg/g)	10.39±0.64 ^a	13.27±0.28 ^b	14.65±0.61 ^c
Soluble collagen (% of total)	20.27±3.09 ^a	20.06±0.31 ^a	18.65±0.56 ^a
Myoglobin content (mg/g)	8.36±1.24 ^a	10.31±0.42 ^a	10.72±0.55 ^a
Shear force (g)	3293.20±104.03 ^a	5634.37±320.81 ^b	5490.27±164.01 ^b
Cooking loss (%)	27.77±2.62 ^a	31.73±4.79 ^a	27.39±0.13 ^a
Color profile			
L*	50.83±2.17 ^a	45.27±4.11 ^{ab}	40.15±4.63 ^b
a*	3.82±0.50 ^a	4.84±1.05 ^a	5.28±2.02 ^a
b*	8.06±0.59 ^a	9.98±1.84 ^a	11.14±1.72 ^a

^{a-c} Means within the same row having the same superscript are not significantly different ($P \geq 0.05$).

those found by other authors (Arguello *et al.*, 2005). Fat content of goat meat ranged from 1.14% to 3.16% ($P < 0.05$) and increased in accordance with goat age. The meat of 7-y Sn x Nt goat had significantly high fat content, probably due to the age and characteristic of the dairy breed. However, the often quoted standard composition of normal adult mammalian muscle is 75% water, 19% protein, 2.5% fat and 0.65% minerals (Lawrie, 1998). These values may vary considerably with factors such as breed, age, sex, weight, and nutritional history. Goat meat obtained from 1-y Ag x Nt contained lower total collagen than those of the 3-y Ag x Nt and 7-y Sn x Nt goat, respectively ($P < 0.05$). However, no significant difference among groups was obtained for soluble collagen content. The collagen contents found in this study were higher compared to those observed by Arguello *et al.* (2005) in kid meat. Myoglobin content of meat from 1-y Ag x Nt goat was significantly lower than meat from 3-y Ag x Nt and 7-y Sn x Nt goat. This result was concomitant with a^* value of the goat meat. The 1-y Ag x Nt goat meat had higher L^* but lower a^* and b^* value than did 3-y Ag x Nt and 7-y Sn x Nt goat meat, respectively. The data obtained could indicate that the meat from younger animal possessed lighter meat color than the older. However, the influence of the breed on goat meat color needs to be further studied. The shear force value of meat from 1-y Ag x Nt was significantly lower than those of 3-y Ag x Nt and 7-y Sn x Nt ($P < 0.05$). The differences in shear force value between meat from 1-y and 3-y Ag x Nt could be attributed to differences in collagen content. The cooking losses of meat from three groups of goat were not significant difference. However, the meat from 3-y Ag x Nt showed the highest in cooking loss which were in accordance with the shear force value. The shear force values obtained in this study were similar to those observed by Swan *et al.* (1998) using Cashmere goat and Babiker *et al.* (1990) using Desert goats, but were lower as compared to the studies of Sheradin *et al.* (2003) in Bore goat (11.4 kg) and Simela *et al.* (2004a) in South African indigenous goats (74.8 N). The acceptable limit for goat meat tenderness was not found in literatures. Warner-Bratzler shear force (WBS) about < 3 kg is noted for the acceptable limit of lamb tenderness (Watanabe *et al.*, 1996; Bickerstaffe, 1996). Beyond 6 kg WBS lamb is considered unacceptably tough. Therefore, the shear force values obtained from this study suggested that those of 3-y Ag x Nt and 7-y Sn x Nt goat meat did not readily attain a highly acceptable degree of tenderness.

3.2 Heat penetration of canned goat meat products

The three groups of goat meat in control media (water) were not significantly different in heat penetration during processing at 118°C to F_0 values of 7.5, although the fat and collagen content in meat were significantly different among groups. The differences in heat penetration of goat meat products were influenced by type of media used. As shown in Table 2, goat meat processed in 5% NaCl brine delayed heat penetration by 7% as compared from control

Table 2. Heat penetration time of canned goat meat in different types of media

Type of media	Heat penetration at 118°C to obtain $F_0 = 7.5$ (min)
Water	18.67 ± 0.58 ^a
Brine	20.00 ± 1.00 ^a
Oil	29.33 ± 2.08 ^b
Massaman curry	56.33 ± 1.15 ^c

^{a-c}Means within the same column having the same superscript are not significantly different ($P \geq 0.05$).

media. This is probably due to the salt solution increasing the water-holding capacity of meat protein during process resulting in swelling of meat and resisting the circulation of the liquid part in can leading to slow heat penetration rate. Markedly slow heat penetration rates were observed in canned goat meat filling by oil and massaman curry. The viscosity and solid content of the media were noted to be one of critical factors for heat penetration of the product (Lopez, 1987). The oil and curry used in this study had higher viscosity as compared to the control media. This could contribute to the slower heat penetration rate.

3.3 Quality characteristics of canned goat meat during storage

The drained weights of canned goat meat in water, oil, brine and curry during storage are presented in Figure 1. Canned goat meat in water and oil had a non-significant increase in drained weight while significant results were obtained in brine and curry ($P < 0.05$). Goat meat processed in curry had higher drained weight than in brine, water and oil, respectively ($P < 0.05$). The 3-y Ag x Nt goat meat had the highest drained weight among treatments.

The hardness of all treatments goat meat was dramatically decreased ($P < 0.05$) after storage for almost 20 days (Figure 2). The 3-y Ag x Nt and 7-y Sn x Nt goat meat did not have significantly different hardness, but were higher than that of 1-y Ag x Nt goat meat ($P < 0.05$). The results were in accordance with the shear force of raw goat meat which was related to the collagen content. The hardness of goat meat processed in massaman curry was significantly lower than that of meat in oil, brine, and water, respectively. The differences among treatments might contribute to the differences in heat penetration time to equivalent F_0 value. The longer time to heat has been reported to solubilise more collagen resulting in increased tenderness of muscle (Voller-Reasonover *et al.*, 1997).

Figure 3 presents the springiness of canned goat meat during storage. No change in springiness during storage was observed for processed 1-y Ag x Nt in water, oil and curry. The springiness of processed older goat meat was slightly increased after storage for 30 days ($P < 0.05$). However, there

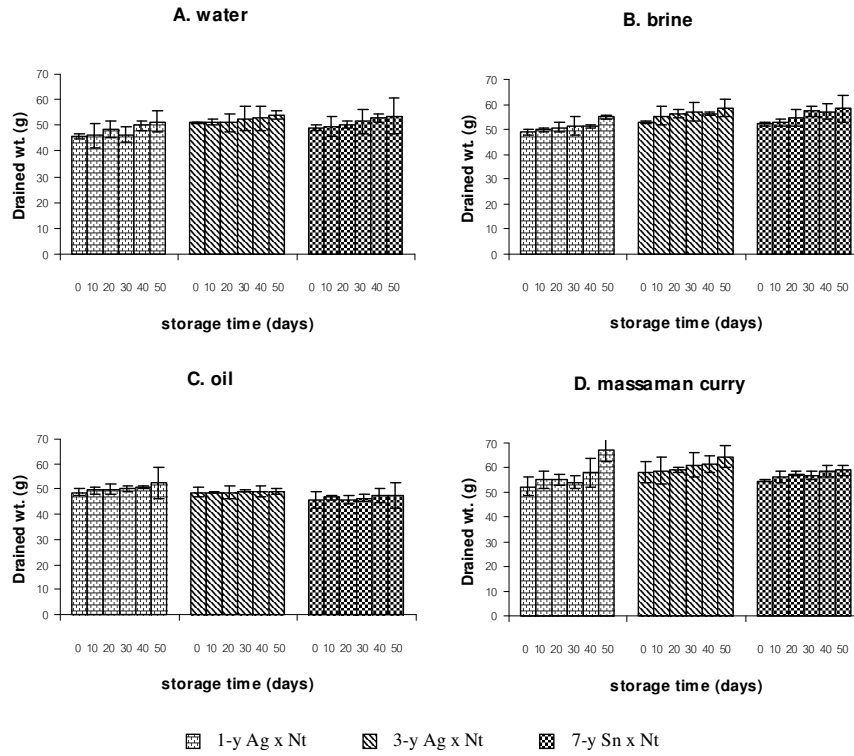


Figure 1. Drained weight of canned goat meat in water, brine, oil and massaman curry during storage at room temperature (1-y Ag x Nt = one year Anglonubian crossed native, 1-y Ag x Nt = three years Anglonubian crossed native, 7-y Sn x Nt = seven years Saanen crossed native)

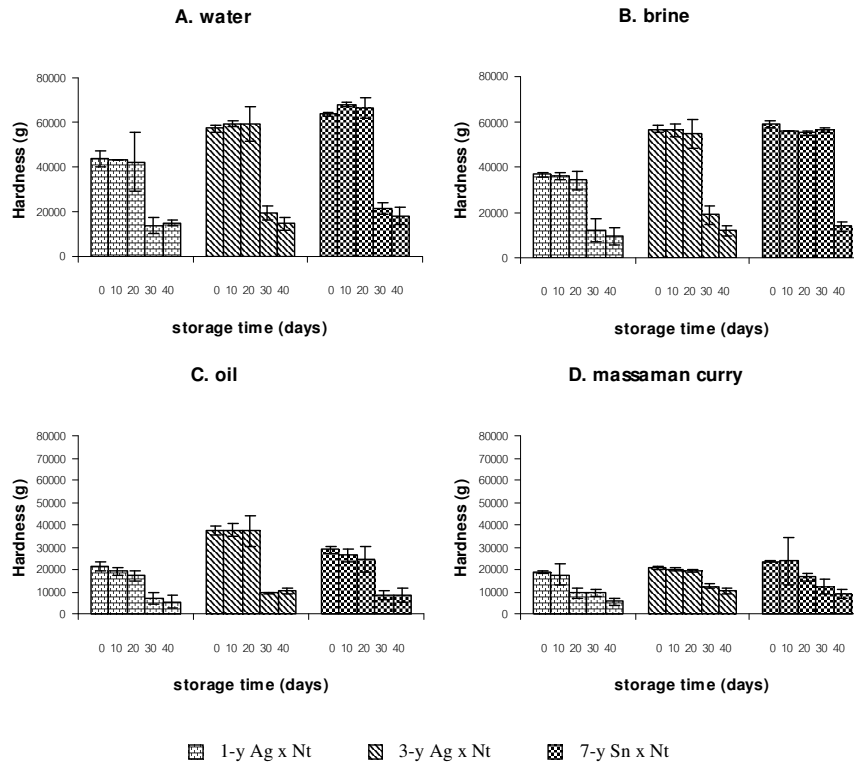


Figure 2. Hardness of canned goat meat in water, brine, oil and massaman curry during storage at room temperature (1-y Ag x Nt = one year Anglonubian crossed native, 1-y Ag x Nt = three years Anglonubian crossed native, 7-y Sn x Nt = seven years Saanen crossed native)

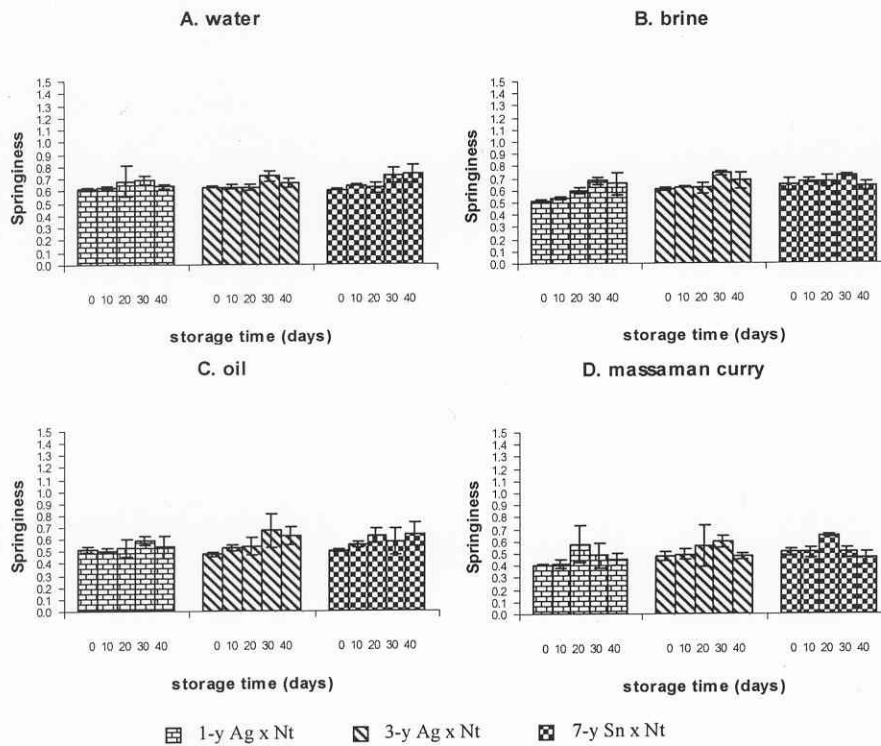


Figure 3. Springiness of canned goat meat in water, brine, oil and massaman curry during storage at room temperature (1-y Ag x Nt = one year Anglonubian crossed native, 1-y Ag x Nt = three years Anglonubian crossed native, 7-y Sn x Nt = seven years Saanen crossed native)

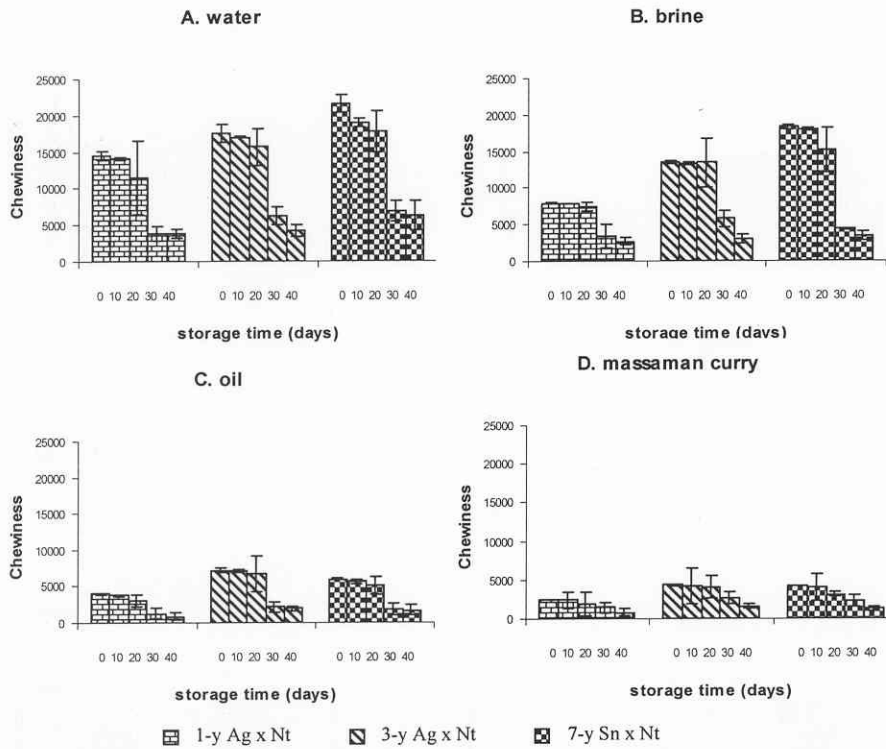


Figure 4. Chewiness of canned goat meat in water, brine, oil and massaman curry during storage at room temperature (1-y Ag x Nt = one year Anglonubian crossed native, 1-y Ag x Nt = three years Anglonubian crossed native, 7-y Sn x Nt = seven years Saanen crossed native)

were no significant differences among groups of goat meat in springiness. Goat meat processed in oil and curry had slightly lower ($P < 0.05$) springiness than meat processed in brine and water. The chewiness of all processed goat meat was not changed during storage for 20 days and then markedly decreased during 30-40 days of storage (Figure 4). A difference among groups of goat meat in chewiness was found when processed in water and brine. The 1-y Ag x Nt goat meat was lower in chewiness compared to the others ($P < 0.05$). The chewiness of all groups of goat meat was much lower when processed in oil and curry.

Storage time had no significant effect ($P > 0.05$) on L^* , a^* and b^* values of canned goat meat (Figure 5, 6, 7). A higher average L^* value was observed in canned goat meat from 1-y Ag x Nt than from the others groups ($P < 0.05$). The lowest L^* value and the highest b^* value were obtained for goat meat processed in massaman curry. This was due to the characteristic color of curry which was adsorbed to the meat.

Lipid oxidation of all goat meat processed in different types of media during storage was evaluated using the determination of TBARS (Figure 8). For all treatments, TBARS values increased at the beginning of storage ($P < 0.05$) and then began to decrease after 20-30 days storage ($P < 0.05$). According to Melton (1983), although malonaldehyde is a secondary product of lipid oxidation, it does not necessarily mean that the TBARS number continues to increase throughout storage. These low TBARS numbers are thought to be the result of malonaldehyde reactions with

proteins. The TBARS value behavior of goat meat samples found in this study were also observed in other goat meat products by Nassu *et al.* (2003). Zapata *et al.* (1990) reported that dry salted lamb were also demonstrated similar results for TBARS values. At the beginning of storage, the canned goat meat from 1-y Ag x Nt in water had lower TBARS value than those of 3-y Ag x Nt and 7-y Sn x Nt meat ($P < 0.05$), respectively (Figure 8A). This result was concomitant with the fat content of the raw meat. Processed 3-y Ag x Nt goat meat in brine obtained similar result to control media. However, as compared to the control, TBARS value of 1-y Ag x Nt was increased while that of 7-y Sn x Nt was decreased when processed in brine (Figure 8B). Differences in fatty acid composition of goat meat might be contributed to differences in lipid oxidation of processed meat in brine. The effect of age and breed on fatty acid profile of goat meat and lipid oxidation should be further investigated. A reduction of TBARS value was observed in goat meat processed in oil at the beginning of storage (Figure 8C). The reason for this result is still unknown. Addition of antioxidant in commercial soya oil was suspected to contribute to the low TBARS value in canned goat meat. Figure 8D shows the TBARS value of processed goat meat in massaman curry during storage, which was the lowest value ($P < 0.05$) as compared to those in the other types of media. This is probably due to the curry containing many spices which could function as natural antioxidants.

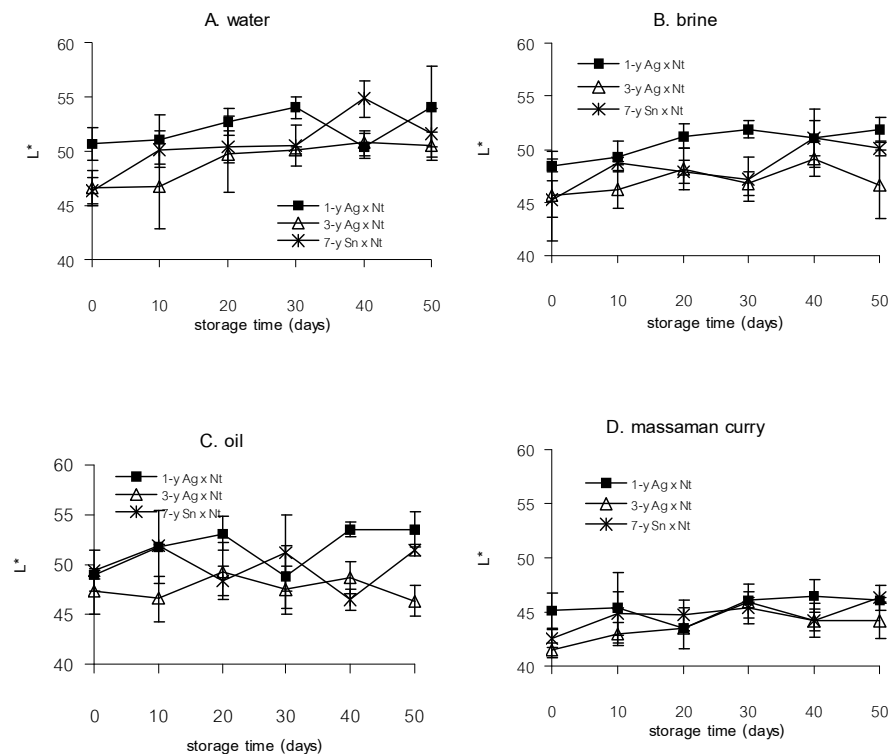


Figure 5. Color L^* of canned goat meat in water, brine, oil and massaman curry during storage at room temperature (1-y Ag x Nt = one year Anglonubian crossed native, 1-y Ag x Nt = three years Anglonubian crossed native, 7-y Sn x Nt = seven years Saanen crossed native)

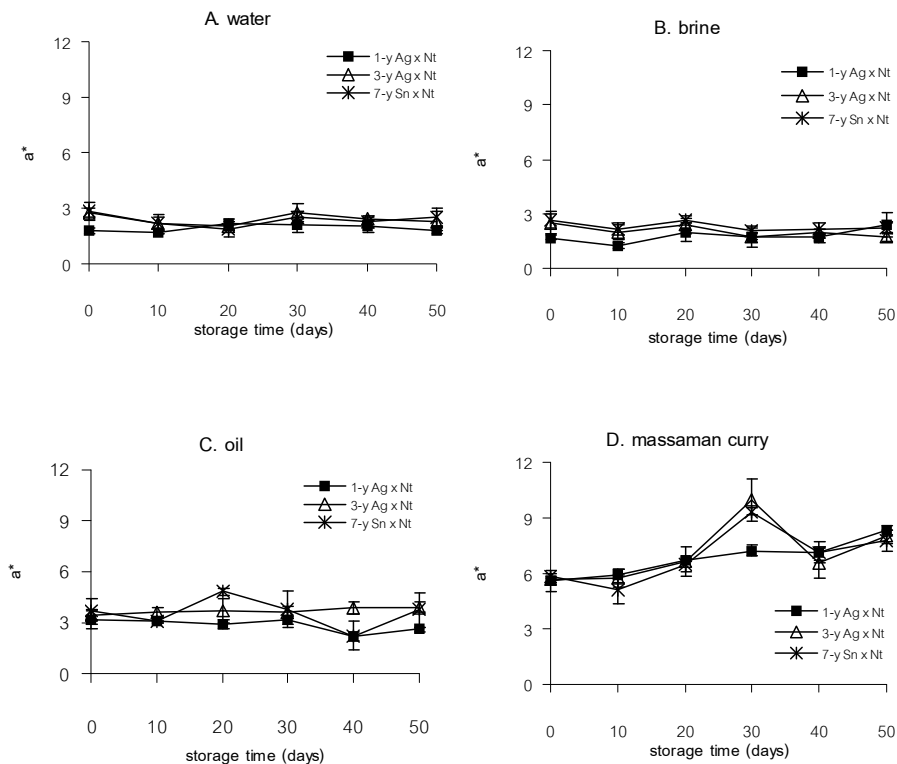


Figure 6. Color a^* of canned goat meat in water, brine, oil and massaman curry during storage at room temperature (1-y Ag x Nt = one year Anglonubian crossed native, 1-y Ag x Nt = three years Anglonubian crossed native, 7-y Sn x Nt = seven years Saanen crossed native)

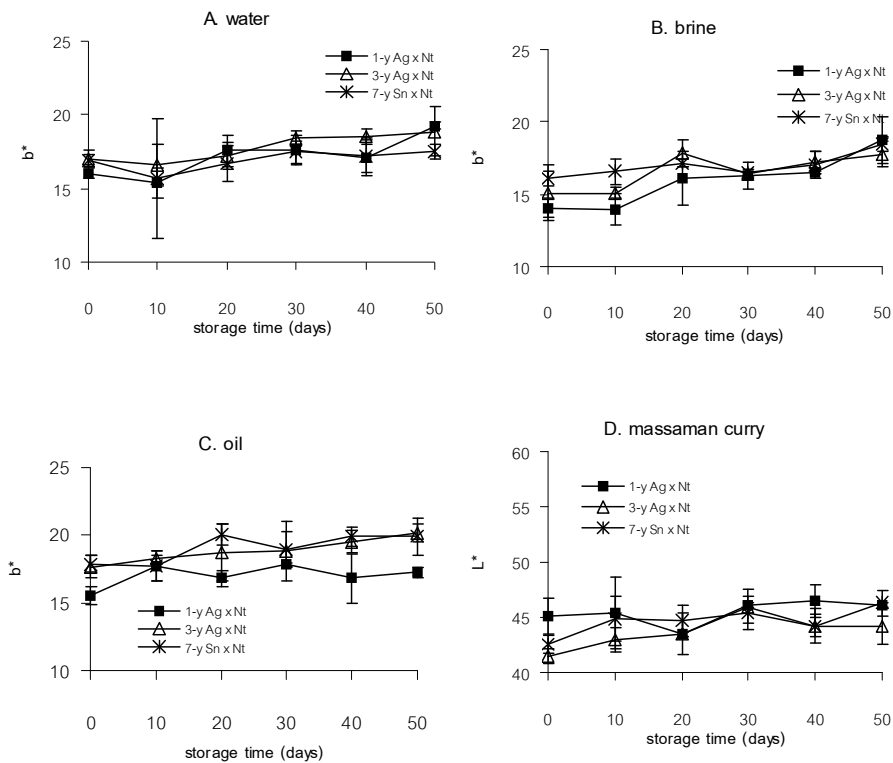


Figure 7. Color b^* of canned goat meat in water, brine, oil and massaman curry during storage at room temperature (1-y Ag x Nt = one year Anglonubian crossed native, 1-y Ag x Nt = three years Anglonubian crossed native, 7-y Sn x Nt = seven years Saanen crossed native)

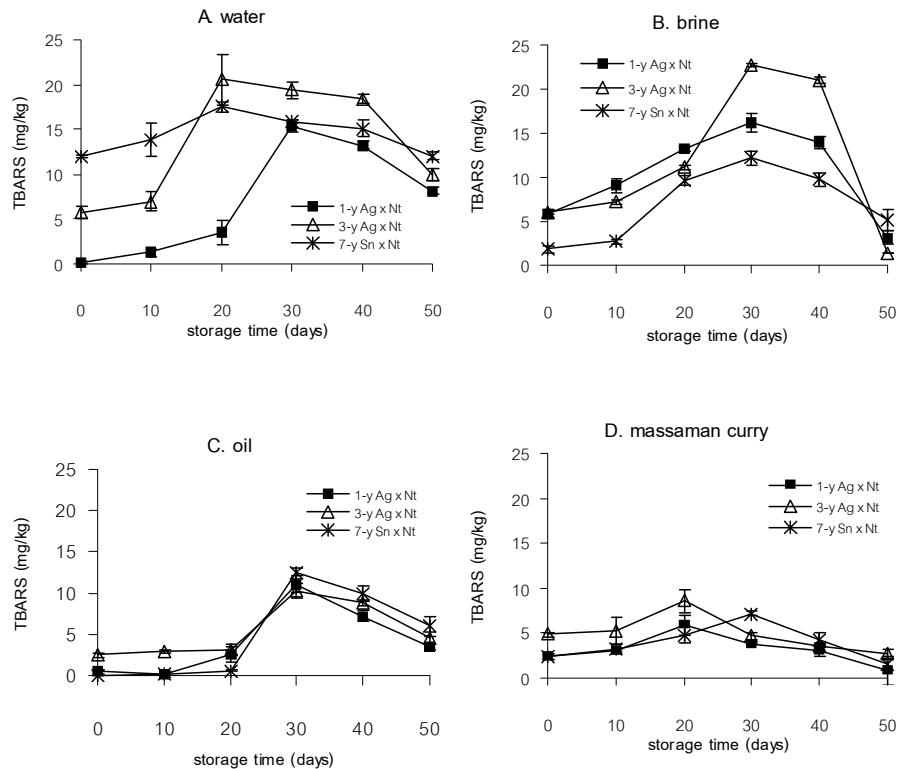


Figure 8. TBARS values (mg malonaldehyde/kg meat) of canned goat meat in water, brine, oil and massaman curry during storage at room temperature (1-y Ag x Nt = one year Anglonubian crossed native, 3-y Ag x Nt = three years Anglonubian crossed native, 7-y Sn x Nt = seven years Saanen crossed native)

4. Conclusions

Three groups of raw goat meat used in this study had significant differences in fat, ash and total collagen content. The meat from younger goat was lighter in meat color and more tenderness. Chemical composition and physical properties of raw goat meat from 3 years Anglonubian crossed native and 7 years Saanen crossed native were similar. Medium types used for canned goat meat had a significant effect on heat penetration time of products while a non-significant effect was observed for the groups of goat meat. Some quality characteristics of canned goat meat changed during storage for 50 days. Canned goat meat processed from 3 years Anglonubian crossed native increased in drained weight more than the other two groups of goat meat during storage. Using brine and massaman curry as a filling media resulted in significant increase in drained weight of the meat. Three years Anglonubian crossed native and 7 years Saanen crossed native goat meat had more hardness and chewiness than one year Anglonubian crossed native when processed in water and brine media. Medium types had more influence on texture of canned goat meat than the groups of meat. Canned goat meat was markedly reduced in hardness and chewiness when processed in massaman curry and oil media. However, medium types and groups of goat meat did not affect canned

goat meat springiness. Storage time had a significant effect on texture of canned goat meat, especially after 20 days storage, resulting in dramatically reduced hardness and chewiness. TBARS values of canned goat meat changed during storage in the same behavior for all treatments. A significance influence of groups of goat meat on TBARS value relating to fat content of raw meat was observed when processed in water and brine. Massaman curry could reduce the change in TBARS value of canned goat meat during storage. Medium types and groups of goat meat used in this study did not have a significant effect on canned goat meat color during storage. The results based on texture, color and lipid oxidation suggested that there were no significant differences between the groups of goat meat from three years Anglonubian crossed native and seven years Saanen crossed native for being processed in canned goat meat value added products.

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