Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(5): 56-64
Received: 05-07-2018
Accepted: 10-08-2018

RAUJ Marapana
Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka

HAD Nayanarasi
Department of Animal Science, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka

S Senanayaka
Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka

PRD Perera
Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka

KHGK Kodagoda
Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka

Correspondence
RAUJ Marapana
Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka

Effect of processing conditions on quality of chicken sausages stuffed in different casings

RAUJ Marapana, HAD Nayanarasi, S Senanayaka, PRD Perera and KHGK Kodagoda

Abstract
Freezing and chilling are the main low temperature preservation methods of meat products. Three types of Chicken sausage sample were prepared using Hog, Sheep and Devro (collagen) casings as a stuffing material and artificial (cellulose) used as control sample. Samples were vacuum packed and stored for 3 months at chilling (0 - 4^0C) and freezing (-18^0C) (slow and quick) conditions. Sample stuffed in sheep casing showed highest (11.84±0.22 %) cooking loss. Sample stored in chilling temperature shown the highest microbial count (1.9×10^6 cfu/g) within 2 weeks and lowest pH (6.57±0.04) which affect the sensory properties.

Water holding capacity decreased in all types of casings with time. Storage temperatures significantly (P<0.05) affect the Lightness*(L*). Processing conditions have a significant (P<0.05) effect on texture of sausages. The highest purge loss observed (3.48±0.01%) in artificial casing with large diameter (28 mm). Microbial count was highest ($7.5*10^5$cfu/g) in sheep casing, but within the acceptable level. Quick frozen and unthawed samples have a longer shelf life than 3 months. Therefore quick freezing is the best method of storage than chilling and slow freezing methods.

Keywords: chicken sausage, casings, hog, sheep, collagen, cellulose

Introduction
Sausages as processed meat products are used in different and diverse cultures around the world (Savadkoohi *et al.*, 2014) [1]. Sausage has evolved as a very diverse meat product. Many varieties have been developed, influenced by climate, religion, and availability of ingredients. Although sausage has been around for hundreds of years, food science, borne from both financial and public health interests, is a relatively new development. Natural and artificial casings are used as forms and containers for sausages. The casings bind and protect the delicacy of the sausage mixture; they regulate contraction and expansion of the sausage. Natural casings are mainly derived from small and large intestines from sheep, goats and pigs, but also from cattle and horses. Natural casings are strong enough to handle pressure during charging, permeable to water vapor, gases and smoke, elastic, firmly adhere against sausage stuffing and can be bound or clipped at the end of sausage. Artificial casings can be made from natural materials (Cellulose and Collagen) or from synthetic thermoplastic materials (Polyamide, Polyethylene, Polypropylene, Polyvinylidene Chloride and Polyester (Heinz and Hautzinger, 2007) [2]. In selecting a suitable casing the most important casing characteristics, which affect not only the final shape and weight of sausage, parallel to the physical integrity which is necessary to maintain all the technological steps in the production of the final product certainly are mechanical strength and permeability to water and gases (Savic and Savic, 2002) [3].

Low temperature and high temperature preservation are two types of products preservation techniques. Desired effects of freezing are that water is made unavailable for growth of microorganisms by being in the form of ice. Exception of water and fat, very little happens to the components of sausage as it is frozen. Freezing procedure and freezer storage influence sausage quality attributes such as thawing loss, color and tenderness (Farouk and Swan, 1998; Honikel *et al.*, 1986) [4, 5]. This is explained mainly by the degree of structural damage caused by formation of ice crystals and the size of these, which is determined by the freezing rate, and which is important for the degree of damage (Grujić *et al.*, 1993; Martino *et al.*, 1998) [6, 7]. However, prolonged freezer storage has been found to level out effects of freezing rate (Ngapo *et al.*, 1999) [8] which is suggested to be a consequence of re-crystallization of small crystals into bigger crystals during long-term freezer storage (Farouk *et al.*, 2003) [9].

When water freezes, it expands by nine percent in volume while forming ice crystals that vary in size depending on the rate of freezing. With rapid freezing, tiny ice crystals are formed.

Slow freezing forms large crystals. If crystals are too large, they may damage the structure of cell walls, which upon thawing, causes juice loss, nutrient loss and unacceptable appearance. When freezing fast, the formed ice crystals are smaller as the freezing of water happens so rapidly that doesn't allow time for ice crystals to grow larger and the damage to the internal sausage structure will be smaller too. Its nutritional value is identical to that of fresh products. In both quick and slow freezing, the temperature is ended up with -18^{o}C. In chilling the temperature ranges between 0 to 4^{o}C. The prime purpose of chilling is to limit the growth of both pathogenic and food spoilage microorganisms. Physical changes occur during frozen storage are recrystallization, freezer burn, moisture migration and thawing. Storing the product properly and under best condition possible will extend its life to its maximum potential. Storage life is the storage period from the time of freezing for as long as the product maintains its organoleptic and nutritive characteristics and is suitable for human consumption. Physical characters (appearance, texture), sensory characters (color, smell, taste, odor, texture), chemical characters (moisture, fat and protein percentage) and microbial characters are the main quality characters, which measure the quality of a product during storage under frozen or chilling condition. Under freezing condition many physical changes happen to the product, which leads to alternate the flavor, appearance and meat texture of the product. Even in transport from the factory to retail shops, there is no -18^{o}C temperature inside the vehicle, which products are transporting. These conditions may affect the quality of the product. Therefore this study was aimed to investigate the effect of storage temperatures (chilling and freezing (slow and quick), casing type, diameter of the sausage and the effect of thawing on quality of skin on quality of chicken sausages.

Materials and Methods

Sample preparation

Sausage sample was prepared in leading meat processing factory in Sri Lanka. Chicken boneless meat (Mechanically Separated Meat, [MSM]) were thawed for 30 minutes. Thawed raw broiler chicken meat and MSM was minced using 8mm plated mincing machine (KE-14). The meat batter was prepared using vacuum salt, nitrate salt, synthetic coloring, ice, chilled water, binders, spices and fat emulsion for 10 minutes to obtain 6 kg of batter. The batter was divided into four 4 portions and was filled into Hog, Sheep, Collagen (Devro) and cellulose (Viscofan) casing to obtain skinned sausages of weights 50, 25, 50 and 50g, respectively. Stuffed sausages were hung on smoking trolleys and subjected to series of cooking events for 1.5 hours until the core temperature reached 72^{o}C. Cooked sausages were kept under shower (at -8 ^{0}C) for 15 to 20 minutes to reduce the temperature of product and to wash out the contaminants present in the outside of casing. Then the sausages were vacuum packed in low density polythene using vacuum sealer (KE-29).

Treatments

For the experimental purpose set of vacuum packed sausage samples were subjected to

Chilling at 4 ^{o}C

Slow freezing (-18 ^{o}C)

Quick freezing (-18 ^{o}C)

Thawing for 6 hours and refreezing

Freezing without thawing

Determination of cooking loss

After 24 hours of thermal processing cooking loss was determined before the storage according to Visessanguan *et al.*, (2004) [10]. Gelled batters were removed from the casing, blotted dry with a paper towel, and weighed. Percentage of cooking loss was expressed as:

$$\textit{Cooking Loss}\ (\%) = \frac{(A - B) - C}{A - C} \times 100$$

A - Stuffed batter weight (raw batter + casing) (g),

B - Cooked and blotted gel weight (g),

C - weight (g) of the casing.

Purge during storage

Purge loss (PL) during storage was determined according to method of Pietrasik & Li-Chan (2002) [11]. Gel samples (20 mm dia. × 15 mm thickness slices) were vacuum packed (-800 Mbar, Multivac, Germany) and stored as a single layer at 4° C. After 1 week, the outer package was removed, slices were blotted and reweighed.

$$\textit{Purge Loss}\ (\%) = \frac{X - Y}{X} \times 100$$

Where X and Y were, respectively, the gel weights before and after storage in gramms.

Colour

Colour of the meat gels were measured using a spectrocolorimeter (Shanghai Precision Science Iinstrument Company Ltd) and expressed as CIE (Commision Internationale de l' Eclariage) L* (Lightness) a* (redness) and b* (yellowness) values. The results are expressed as the average values obtained by taking observations from three different cut surfaces of the same gel.

Analysis of Organoleptic Properties

Samples were tested for organoleptic properties (Appearance, Color, Flavor, Texture and Acceptability) by 30 untrained panelist using 5-point hedonic scale.

In first two weeks, samples from each condition were coded and they were presented for evaluation with the prepared sensory evaluation sheet. After two-week interval chilled sample was removed from the evaluation and others were presented for evaluation.

Analysis for keeping quality characters

The measurements were taken for the pH, Water holding capacity (WHC), PL, Color and Texture. pH was measured using a digital pH meter at 27^{0}C. To measure the WHC, each sample was centrifuged at 2600 rpm for 4 minutes using centrifuging machine (Mettler PE 300). Three slices were cut from each sausage sample and weighed. Then they were vacuum packed and placed in a single layer at 4 ^{0}C.

L*, a* and b* values of every samples were taken which represents lightness, redness and yellowness respectively by using a chromo meter (Minolta cv/300). From each sample, L, a, b values were taken from three places. All samples from each condition were cut in to piece of same length (2cm length). Then a piece was placed on the tender meter (Instron N 4465) and the meter was started. After the whole piece was cut in cross sectional, the final cuttings force value (hardness), was appeared on the displaying screen.

Tenderness was determined by cutting muscle cores (1 cm^2 in cross-section and 3 cm long) parallel to the muscle fibres. Core samples were then subjected to shear force analysis using a Warner-Bratzler shear force device (INSTRON 4465, Instron Inc., Barcelona, Spain).

Microbiological Analysis

Samples were analyzed for Total Plate Count (TPC), *Salmonella*, *Escherichia coli* and *Staphylococcus aureus* using standard methods.

For the determination of *E. coli*, one milliliter from the blended sausage sample (10^{-1} dilution) was introduced aseptically on to the Petri Film and the cover slip was closed. The Petri Film was incubated at 32^0C for 48 hours and black colored spots, which surrounded by the bubbles were counted as colonies. *Staphylococcus aureus* was determined by using Baird parker medium. Initially 0.1 ml of blended sausage sample was introduced into two Baird parker plates and were incubated at 35 ^{0}C for 24 to 48 hours. Gray–black shiny convex colonies of 1-1.5 mm diameter (in 18 hours) up to 3 mm (in 48 hours) and narrow white entire margin surrounded by clear zone of 2.5 mm were counted.

For the determination of TPC, 1 ml of sausage sample (10^{-2} dilution) was introduced to the Petri Film and the cover slip was closed and incubated at 32^0C for 48 hours.

Proximate composition analysis

The proximate composition of the initial sausage sample from chilled, slow frozen, quick frozen, thawed, unthawed and control samples and after 3 months of storage were determined according to AOAC methods (2000) [12].

Statistical analysis of data

Statistical analysis was performed by Minitab-17 Software and the gathered data were analyzed at 95% confidence interval. All the values were reported as mean ± Standard deviation (SD) where n=3.

Results and Discussion

Effect of Storage Temperatures on Keeping Quality Characters of Sausages

Table 1: Keeping quality characters of sausage samples stored at chilled, slow frozen and quick frozen conditions after 2 weeks of storage.

Treatment	pH	WHC %	PL %	L*	a*	b*	Tenderness (N)
Chilled	6.57±0.04b	50.4±0.19a	4.51±0.01b	61.55±0.1a	11.47±0.1a	17.77±0.1ab	0.023a
Slow Frozen	7.05±0.03a	41.5±0.09b	4.58±0.01a	60.73±0.9b	11.51±0.2a	14.95±0.1a	0.022a
Quick Frozen	7.04±0.04a	45.6±0.16c	4.58±0.01a	61.96±0.8a	11.66±0.1a	14.41±0.1b	0.028a

Values in the columns with different letters are significantly different from each other (P<0.05)

There was a significant difference (P<0.05) in pH value of the sausage samples based on the temperature of storage. pH of slow and quick frozen sausages after 2 weeks were not significantly different but significantly different with the chilled sausage.

There was a significant effect of storage temperatures on WHC of sausages at 0.05 level of significance. Highest mean value for WHC (50.4 ± 0.19%) was recorded in chilled condition and the lowest mean value (41.5 ± 0.09%) in slow frozen condition. In all conditions WHC was decreased with time. When comparing the WHC in 3 different storage temperatures with the initial WHC, most acceptable storage temperature was 4^0C. Sausages which were kept under -18^0C, had insufficient WHC. Freezing methods have significant effect (P<0.05) on purge loss. The mean value of PL in chilled sample is significantly different from the mean values of the frozen (quick and slow) sausage samples. PL is an important parameter as it influences product appearance, consumer perception, and stability (Triki *et al.,* 2013) [13].

Color is an important parameter that determines the consumer acceptance. Initial lightness (L*), redness (a*), yellowness (b*) values were similar in all the sausage samples before subjecting to different processing conditions. Degree of redness is the general parameter that has been used as colour indicator for the freshness of meat and meat products (Ch'ng *et al.,* 2014) [14].

Meat sausages with higher a* value is desirable and score highest consumer acceptance (Resurreccion, 2004) [15]. As shown in Table1 freezing methods had a significant effect (P<0.05) on L* values of the sausage sample after 2 weeks of storage. There was no significant effect of freezing methods on tenderness.

Effect of casing type on keeping quality characters of sausages.

Table 2: Variation of cooking loss in sausage samples with four different casing types

Treatment	CL % (Mean ± SD)
Sheep Casing	11.84 ± 0.22^a
Collagen Casing	6.34 ± 0.05^b
Cellulose Casing	5.27 ± 0.21^c
Hog Casing	4.57 ± 0.05^d

Values in the columns with different letters are significantly different from each other (P<0.05)

Cooking loss measures the ability of the system to bind water and fat after protein denaturation and aggregation and the amount of liquid lost from the sample during cooking (Tiki *et al.,* 2003; Kerr *et al.,* 2005) [13, 16]. In general, less cooking loss is associated with a juicier product (Kerr *et al.,* 2005) [16]. There was a significant difference on the cooking loss in chicken sausages based on the type of casing. Highest mean value was in sheep casing and lowest mean value was in Hog casing (Table 2). It may be due to the thickness of the Hog casing, which is higher than others and avoid loss of inside materials.

Table 3: Mean values of keeping quality characters in different casing types

Type of Casing	pH	WHC %	PL %	L*	a*	b*	Tenderness (N)
Hog	6.99±0.04^b	43.32±0.14^d	2.37±0.01^d	61.85±1.48^a	12.06±0.4^{ab}	13.59±0.16^b	0.046^a
Sheep	6.68±0.04^b	44.21±0.2^c	3.15±0.01^b	61.80±0.88^a	9.29±0.74^c	15.63±0.6^a	0.021^c
Devro -Collagen	7.01±0.04^b	48.29±0.14^b	3.02±0.01^c	60.92±0.82^a	12.93±0.38^a	12.78±1.41^b	0.026^b
Artificial	7.04±0.02^a	49.99±0.24^a	3.48±0.01^a	62.48±1.75^a	11.70±0.33^b	12.15±0.32^b	0.015^d

Values in the columns with different letters are significantly different from each other (P<0.05)

Casing types has a significant (P<0.05) effect on the pH. Hog and sheep casing were slightly acidic than Collagen and Cellulose casing during 3 months period. Mean pH value of Hog, Sheep and Collagen skin on chicken sausage were significantly different from artificial skin on chicken sausages (Table 3).

In all casing types WHC was decreased with the storage period. There was a significant *(P*<0.05*)* effect of casing types and storage period on WHC. When comparing the WHC in 4 different casing types with the initial WHC, most acceptable casing type was cellulose casing and most unacceptable casing type was the Hog casing. The highest purge loss (3.485±0.01%) was observed in artificial casing and there was a significant difference between the PL of each casing type.

L* values of the sausage samples were not significantly different in all casing types at 95% confidence interval. a* and b* values of the sausage sample with different casing types were significant (P<0.05) in four different casing types. Lowest redness (9.29±0.74) was observed in the sample stuffed in Sheep casing and the highest redness (12.93±0.38) was observed in the sample stuffed in Collagen casing (Table 3).

Redness is viewed as a more important parameter in meat products and the importance of yellowish remained unclear (Juncher *et al.*, 2003) [17]. Meat sausages with L* value between 62.3 and 68.5 were highly accepted by consumers (Dingstad *et al.*, 2005) [18]. There was a significant (P<0.05) effect of casing type on yellowness of the sausage samples after 3 months of storage. Highest b* value (15.63±0.6) was observed in Sheep casing which is significantly different from Hog, Collagen and Cellulose (Artificial) casings (Table 3).

There was a significant (P<0.05) effect of casing types on tenderness. Highest cutting force value was observed in Hog casing (0.04 N), in which the hardness is very much higher than others (Table 3).

Effect of casing diameters on keeping quality characters of sausages

Table 4: Mean values of keeping quality character in sausage samples with different casing diameters

Treatment	pH	WHC %	PL %	L*	a*	b*	Tenderness (N)
Large (36mm)	7.00±0.04^{b}	45.80±0.11^{b}	2.68±0.01^{c}	61.38± 0.12^{a}	12.49±0.08^{a}	13.19±0.08^{b}	0.036^{a}
Small (22mm)	6.98±0.03^{b}	44.21±0.26^{c}	3.15±0.01^{b}	61.80±0.14^{a}	9.29±0.08^{b}	15.63±0.07^{a}	0.021^{b}
Artificial (28mm)	7.04±0.02^{a}	49.99±0.24^{a}	3.48±0.02^{a}	62.48±0.13^{a}	11.70±0.07^{a}	12.15±0.07^{b}	0.015^{c}

Values in the columns with different letters are significantly different from each other (P<0.05)

There was a significant difference (P<0.05) between the pH of the sausages based on the diameter of the casing. pH of the sausages with large diameter and small diameter casing were significantly different from artificial casing. Interaction effect of casing diameters and storage period were also significant at 5% level. There was a significant (P<0.05) effect of casing diameters and storage period on WHC of sausages. Highest mean value (49.99 ± 0.24%) was observed in artificial casing (Table 4).

As shown in above (Table 4), highest purge loss was observed in artificial (28mm) casing. There was a significant (P<0.05) effect of casing diameters on purge loss. Only a* and b* values were significantly (P<0.05) different in all casing diameters. L values were not significantly different with the casing diameter after 3 month period. As shown in above (Table 4), lowest redness (9.29±0.74) was observed in small diameter casing, which is significantly different from large and artificial - cellulose (28mm) diameter casing. Mean value of the b* was highest (15.63±0.6) in small diameter casing which is significantly different from large and artificial - cellulose (28mm) diameter casing. Casing diameters were significantly (P<0.05) affected on tenderness. Casing with large diameter needs high cutting force value than small diameter casing.

Effect of thawing on keeping quality characters of chicken sausage

Table 5: Mean values of keeping quality characters in thawed and unthawed sausage sample with cellulose casing

Treatment	pH	WHC %	PL %	L	a*	b *	Tenderness (N)
Thawed	7.04±0.04^{a}	43.55±0.04^{b}	4.58±0.009^{a}	61.35±0.1^{a}	11.43±0.02^{a}	14.68±0.01^{a}	0.025^{b}
Unthawed	6.99±0.02^{b}	45.27±0.12^{a}	2.85±0.006^{b}	61.52±0.1^{a}	11.59±0.02^{a}	14.00±0.01^{a}	0.031^{a}

Values in the columns with different letters are significantly different from each other (P<0.05)

Initial pH values were same in thawed and unthawed sample. Thawing has a significant (P<0.05) effected on pH. Thawed sample showed a higher value for pH than unthawed sample (Table 5). It may be due to microbial activity in thawing. Interaction effect of thawing and storage period was also significant at 5% level.

There was a significant (P<0.05) effect of thawing on purge loss during storage period. Highest mean value (4.58±0.009%) for purge loss was observed on thawed sample. When thawing was done continuously, it will tend to exude fluid. These drip fluid contains proteins, peptides, amino acids, purine, vitamin B complexes and various salts.

There was a significant (P<0.05) effect thawing on tenderness of the sausages. When thawing was done continuously it may damage the texture of the sausages.

Sensory Evaluation

Effect of storage temperature on sensory properties of chicken sausages

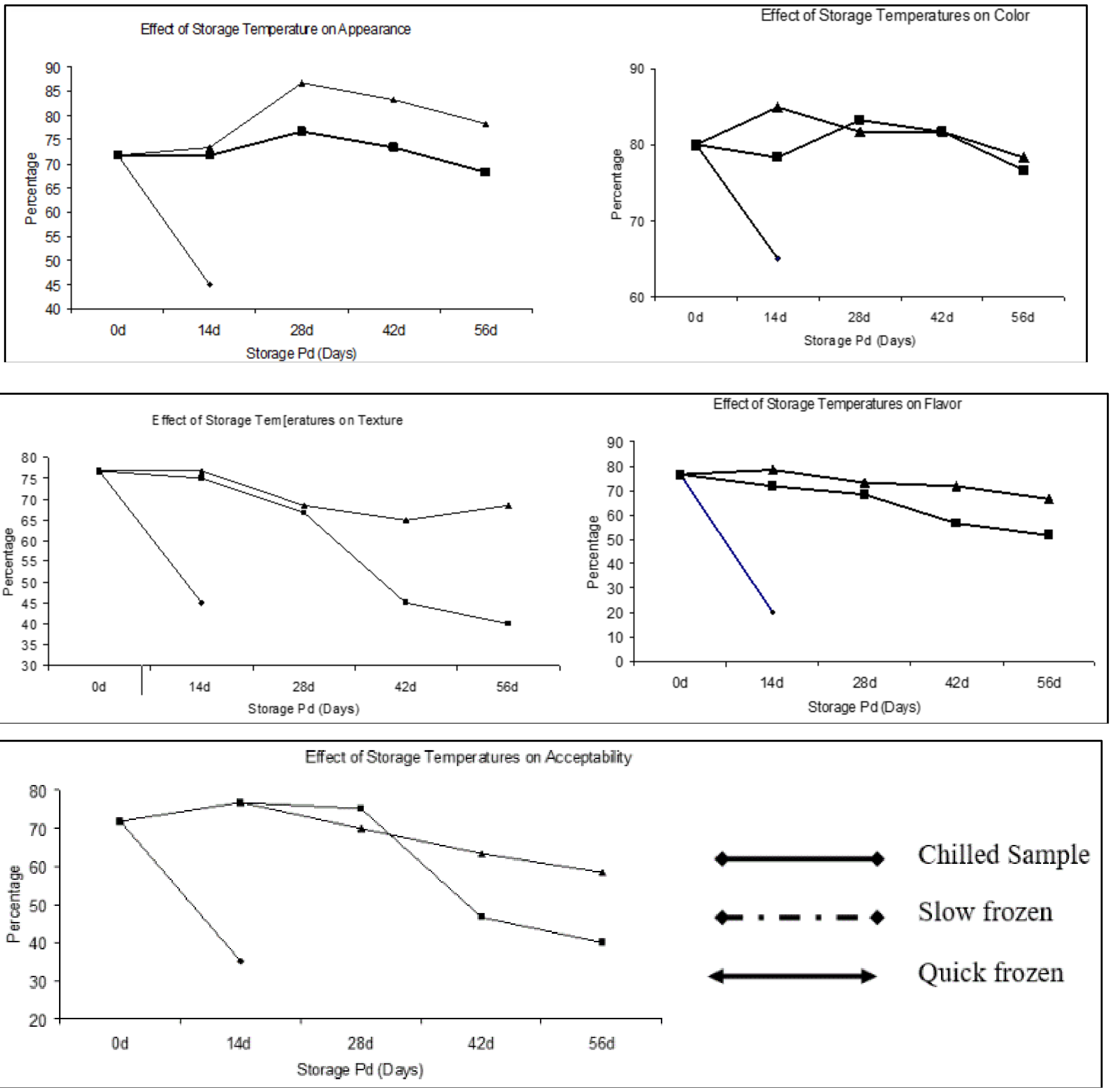
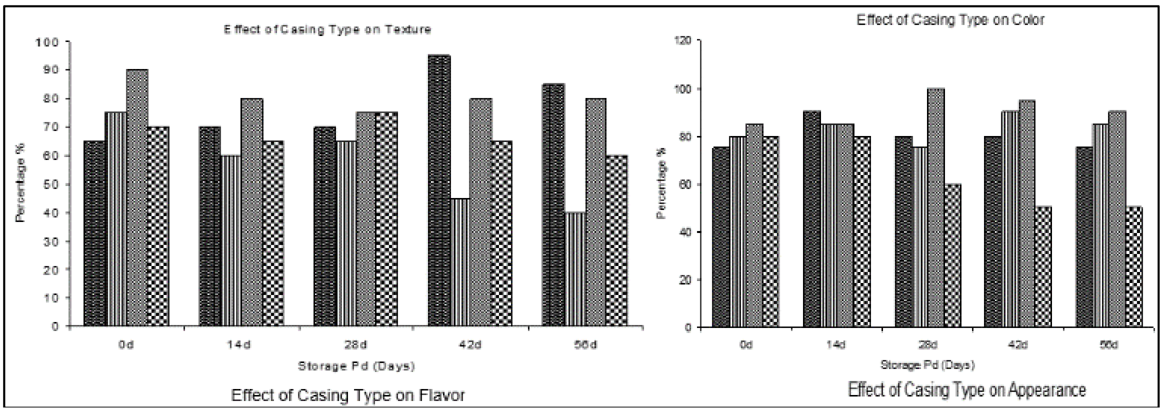


Fig 1: Effect of storage temperatures on sensory characters of sausage samples

In chilled condition sensory characters were reduced within 2 weeks interval. In 4^0C growth of pathogenic and food spoilage microorganisms is not limited. Therefore the shelf life was limited. In frozen samples sensory characters were reduced gradually with the storage time. Texture of the slow frozen sample was highly decreased due to formation of large ice crystals which affect the cell structure than the quick frozen sample. Quick freezing did not alter the product's structure; therefore it was identical to fresh product.

3.5.2 Effect of different casing types on sensory properties of chicken sausages.



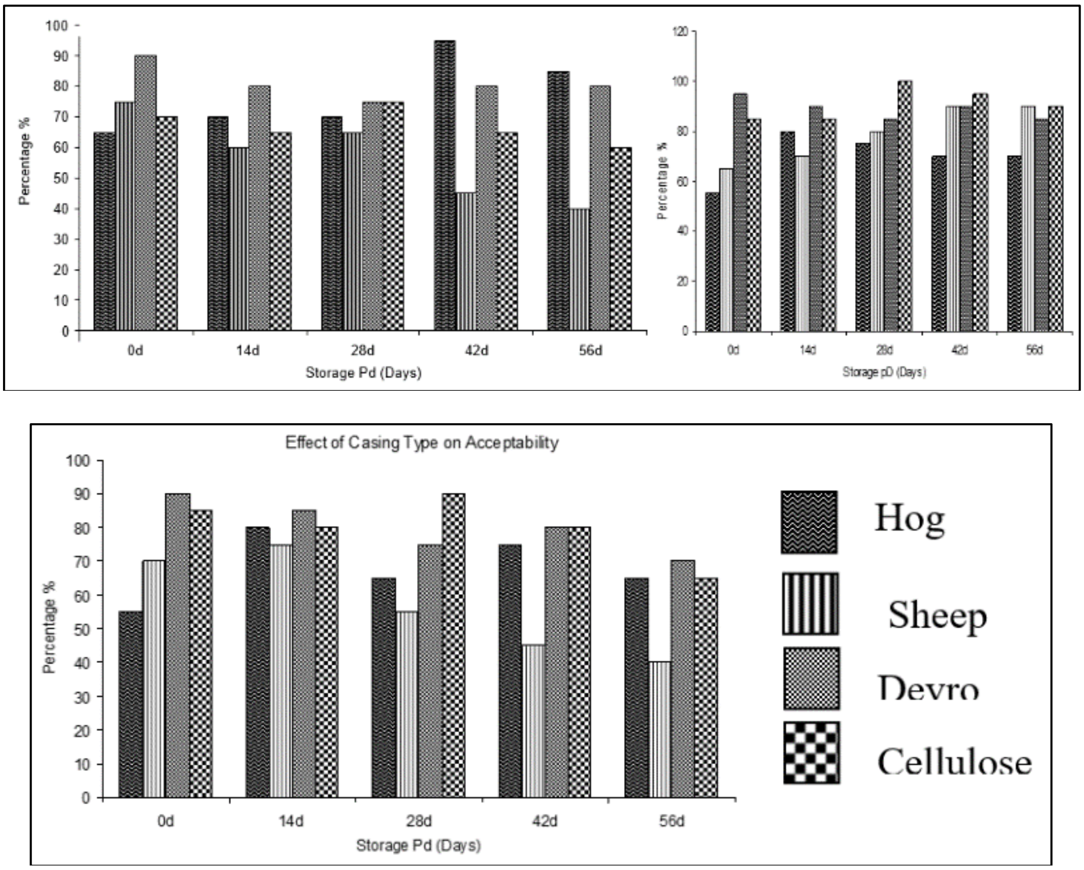
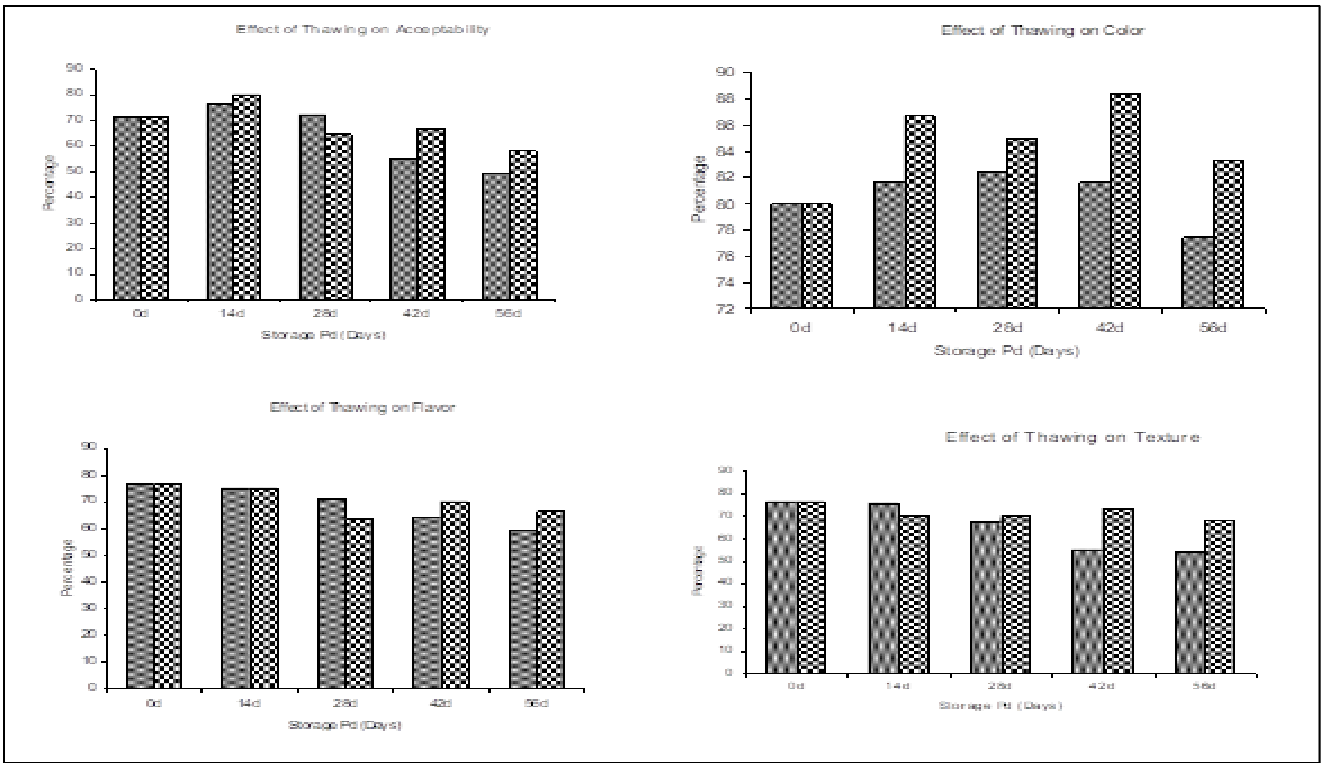


Fig 2: Effect of casing types on sensory characters of sausage samples

Appearance was high in sample stuffed in Collagen and artificial-cellulose casing than Hog and Sheep casings. But in Collagen casing, when the storage period was increasing, wrinkles appeared on the surface which leads to reduction of appearance as the casings have uniform length and shape than natural casings. Color was not changed in all casing types except artificial, which showed lowest tasting panel scores towards the end of storage period. Flavor was high in Hog, Sheep and Devro-Collagen casings at the beginning and reduced with the storage period. But in artificial casing flavor was not desirable at the beginning. But cellulose casing is very thin and allows smoke to penetrate, and moisture to escape during cooking. There is no change in texture of all casing types. The acceptability was high in Devro-Collagen and artificial casing than Hog and Sheep casing.

Effect of thawing on sensory properties of chicken sausages.



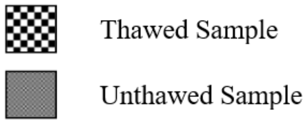


Fig 3: Effect of Thawing on sensory characters of sausage samples during storage period

Appearance, color, flavor, texture and acceptability were same in both samples at the beginning, but at the end of the storage period they were high in unthawed sample than thawed sample. Texture was highly damaged in thawed sample, because repeated freezing and thawing cycles are very detrimental to stored foods. As little as a 3^0C fluctuation in storage temperature above and below -18^0C can be damaging to sausages. Since bacteria survive in the freezing process, when thawing times are long and temperatures of the product increases, there is an opportunity for bacterial multiplication. Therefore the acceptability of the thawed sample was very much lower than the unthawed sample during storage period.

3.6 Analysis of Microbiological Properties

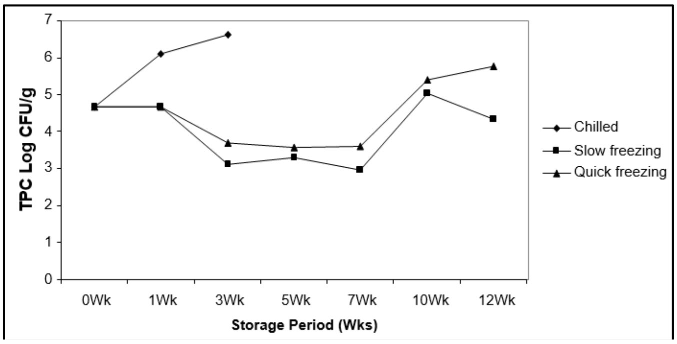


Fig 4: Effect of freezing methods on TPC

Total Plate Count was increased in chilled sample within 3 weeks interval up to unaccepted level. The mean value of chilled sample was 1.85×10^6 cfu/g which exceeded the accepted level of 1×10^6 cfu/g. In slow frozen and quick frozen samples first they decreased within 3 weeks and started to increase after 7th week (Figure 4). But in those samples, TPC were in accepted level even after 3 months period (Mean value of the Slow frozen and Quick frozen samples were 3.37×10^4 and 1.39×10^5 cfu/g respectively).

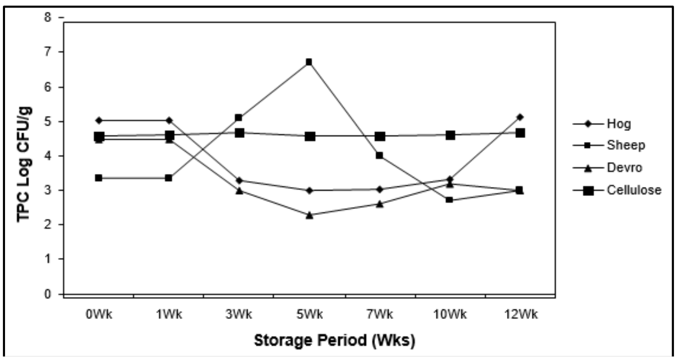


Fig 5: Effect of Casing type on TPC

There was a significant (P<0.05) effect of casing types on TPC with the storage period. As shown in above (Figure 5), TPC were not changed in cellulose casing during 3 months period. In Hog and Devro casings, within 1st week the TPC remained at the initial count, but after 1st week they started to decrease and after 5th week TPC increased gradually. Lowest initial Total Plate count was (2.3×10^6cfu/g) observed in Sheep casing, but in 5th week it showed the highest TPC (5.1×10^6 cfu/g) than other casings.

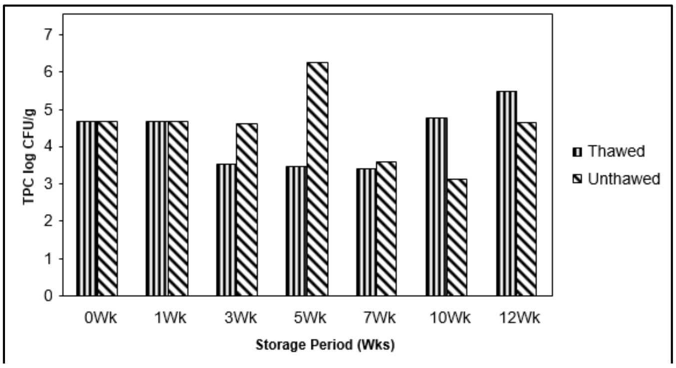


Fig 6: Effect of Thawing on TPC

There was a significant (P<0.05) effect of thawing on TPC. Within 1st week interval the count (4.8×10^4 cfu/g) was same in both conditions. But when thawing was done continuously, TPC was lower (8.6×10^4cfu/g) than the unthawed sample (2.7×10^5 cfu/g) (Figure 6). It may be due to temperature fluctuations during thawing. Just after the sample was thawed, it will refreeze again, so this stress condition may harmful to microorganisms and their proliferation is halted. Therefore the microbial count was decreased in thawed sample than the unthawed sample.

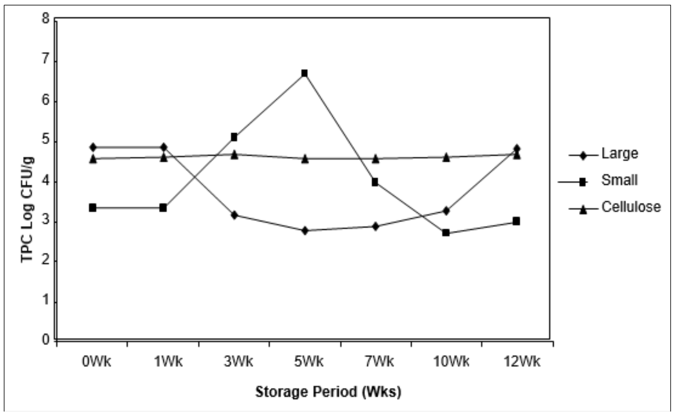


Fig 7: Effect of Casing Diameter on TPC

There was also a significant (P<0.05) effect of casing diameters on TPC during storage period. In 1st week initial TPC remained without changing in each sample with different diameters. In small diameter casing after 1st week TPC were increased up to 5.1×10^6 cfu/g and started to decrease gradually after 5th week. Mean value of TPC in small diameter casing was 7.5×10^6 cfu/g. In large diameter casing, TPC was decreased and started to increase gradually after 5th week (Figure 7). In artificial (28mm) casing TPC (4.2×10^4 cfu/g) remained without changing during 3 months storage period.

Proximate composition analysis of chicken sausages

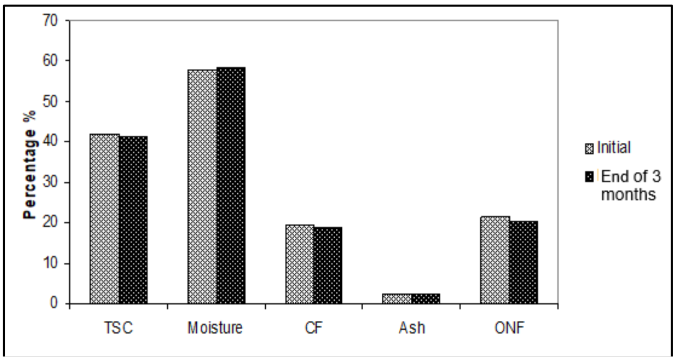


Fig 9: Chemical Composition of Chicken Sausages packed in Devro casing

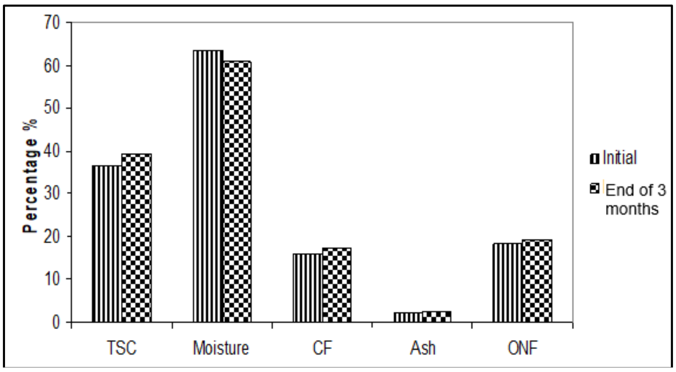


Fig 10: Chemical Composition of Chicken Sausages packed in artificial casing

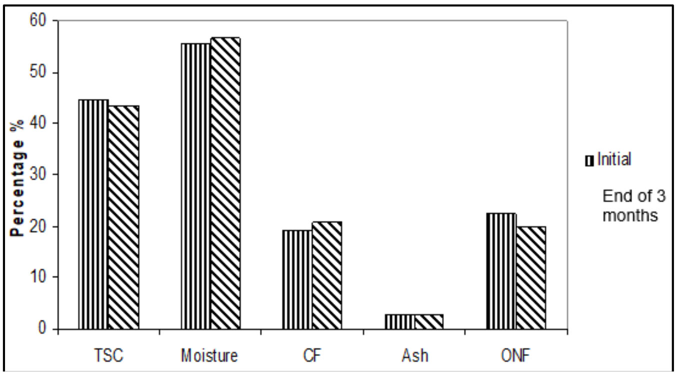


Fig 11: Chemical Composition of Chicken Sausages packed in Sheep casing

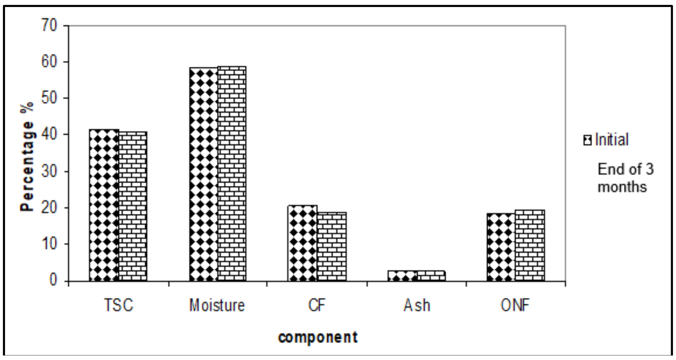


Fig 12: Chemical Composition of Chicken Sausages packed in Hog casing

According to Figure 9, 10, 11 and 12 there was no significant ($P<0.05$) effect of casing type on chemical composition. Crude fat (CF), ash content and organic non-fat (ONF) were not changed after 3 month period. Only moisture content and Total Solid Content (TSC) were changed after 3 months of storage.

Conclusion

Freezing methods (Chilling, Slow freezing and quick freezing) have a significant effect on quality of the sausages at 0.05 level of significance. Maximum storage period for chilled samples was 2 weeks. Quick frozen sample can be stored for more than 3 months, but texture was highly damaged in slow frozen sample than quick frozen sample. Slow freezing forms large crystals, they may damage the structure of cell walls, which upon thawing, causes juice loss, nutrient loss and unacceptable appearance. Artificial casing (Cellulose) & edible Collagen casing (Devro) were the best casing types than Hog and Sheep casings. Texture, Color, Appearance of the thawed sample was highly affected than unthawed sample that was not suitable for consumption even after 3 months period. At the end of the period microbiology characters were satisfactory, but the quality was very much low in thawed sample than unthawed sample.

References

1. Savadkoohi S, Hoogenkamp H, Shamsi K, Farahnaky A. Color, sensory and textural attributes of beef frankfurter, beef ham and meat-free sausage containing tomato pomace. Meat Sci. 2014; 97(4):410-418. doi:10.1016/j.meatsci.2014.03.017.
2. Heinz G, Hautzinger P. Meat Processing Technology for Small to Medium Scale Producers. RAP Publication, Bangkok, 2007.
3. Savic I, Savic Z. Sausage Casings. Edn 1, Victus, Vienna, 2002.
4. Farouk MM, Swan JE. Effect of rigor temperature and frozen storage on functional properties of hot-boned manufacturing beef. Meat Sci. 1998; 49(2):233-247.
5. Honikel KO, Kim CJ, Hamm R, Roncales P. Sarcomere shortening of pre-rigor muscles and its influence on drip loss. Meat Sci. 1986; 16(4):267-282.
6. Grujić R, Petrović L, Pikula B, Amidžić L. Definition of the optimum freezing rate—1. Investigation of structure and ultrastructure of beef *M. longissimus dorsi* frozen at different freezing rates. Meat Sci. 1993; 33(3):301-318.
7. Martino MN, Otero L, Sanz PD, Zaritzky NE. Size and location of ice crystals in pork frozen by high-pressure-assisted freezing as compared to classical methods. Meat Sci. 1998; 50(3):303-313.
8. Ngapo TM, Barbare IH, Reynolds J, Mawson RF. Freezing and thawing rate effects on drip loss from samples of pork. Meat Sci. 1999; 53(3):149-158.
9. Farouk MM, Wieliczko KJ, Merts I. Ultra-fast freezing and low storage temperatures are not necessary to maintain the functional properties of manufacturing beef. Meat Sci. 2003; 66(1):171-179.
10. Visessanguan W, Benjakul S, Riebroy S, Thepkasikul P. Changes in composition and functional properties of proteins and their contributions to Nham characteristics. Meat Sci. 2004; 66(3):579-588.
11. Pietrasik Z, Li-Chan, ECY. Response surface methodology study on the effects of salt, microbial transglutaminase and heating temperature on pork batter gel properties. Food Res. Int. 2002; 35(4):387-396.
12. AOAC. International. Official Methods of Analysis of AOAC. Association of Official Analytical Chemists. Washington DC: AOAC International, 2000.

13. Tiki M, Herrero AM, Jiménez-Colmenero F, Ruiz-Capillas C. Storage stability of low-fat sodium reduced fresh merguez sausage prepared with olive oil in konjac gel matrix. Meat Sci. 2013; 94(4):438-446.
14. Ch'ng SE, Ng MD, Pindi W, Kang OL, Abdullah A, Babji AS. Chicken sausages formulated with gelatin from different sources: a comparison of sensory acceptability and storage stability. World Appl Sci J. 2014; 31(120):2062-2067.
15. Resurreccion AVA. Sensory aspects of consumer choices for meat and meat products. Meat Sci. 2004; 66(1):11-20.
16. Kerr WL, Wang X, Choi SG. Physical and sensory characteristics of low-fat Italian sausage prepared with hydrated oat. J Food Qual. 2005; 28(1):62-77.
17. Juncher D, Rønn B, Hansen TB, Henckel P, Karlsson A, Skibsted LH, *et al.* Effect of pre-slaughter physiological conditions on the oxidative stability of colour and lipid during chill storage of sliced, retail packed roast ham. Meat Sci. 2003; 63(2):151-159.
18. Dingstad GI, Kubberød E, Næs T, Egelandsdal B. Critical quality constraints of sensory attributes in frankfurter-type sausages, to be applied in optimization models. LWT-Food Science and Technology. 2005; 38(6):665-676.