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Shelf Life Determination of Precooked Frozen Meat Dumplings

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Abstract

Quality of frozen foods is significantly affected by the storage temperature and time, and the consumers' demand for safe quality frozen foods is increasing. The objective of this research was to estimate the shelf life of frozen cooked meat dumplings, based on the changes in the selected physico-chemical and sensory quality attributes. Precooked frozen meat dumplings sampled from the same lot produced at a frozen food company in Seoul were stored at −10, −15, and −20°C. The meat dumplings sampled at 3- to 4-week intervals were subjected to the determination of volatile basic nitrogen (VBN), thiobarbituric acid (TBA), peroxide value (POV), surface color and shear value after thawing at 5°C for 15 h. High quality life (HQL) was determined through the triangle test and practical quality life (PQL) through the scoring test. VBN, TBA and POV increased as the storage period was increased. HQL of the frozen meat dumplings were 189 and 252 days at −10 and −15°C, respectively. The estimated PQL were 349, 475, and 491 days at −10, −15, and −20°C, respectively. Statistical analysis indicated that there were significant relationships between sensory scores and VBN and POV of the stored meat dumplings. VBN was selected as the most reliable objective quality index for the shelf life determination (PQL) of the precooked frozen meat dumplings.

Key words: shelf life determination, precooked frozen meat dumplings, quality attributes

Introduction

Quality of frozen foods after storage mainly depends on the storage temperature and time. Time-temperature tolerance (TTT) has been used to illustrate the numerical relationship between the quality of frozen foods and the storage temperature and time (Mcbride *et al.* (1979); Grisius *et al.* (1987)). Attempts were made to estimate the shelf-life of food products based on the quality loss as affected by the storage time and temperature (Labuza (1982); Labuza *et al.* (1992); Singh *et al.* (1976); Fu *et al.* (1993); Kim (1993)). The quality loss of stored meat products could be mainly due to lipid oxidation and protein degradation. Some assays of the degradated products, such as volatile basic nitrogen (VBN), peroxide value (POV), trimethylamine (TMA) and thiobarbituric acid (TBA), could provide useful data for the determination of the shelf life of meat or fish products (Malle *et al.* (1989)).

The frozen dumplings is the most selling prepared frozen food in Korea. It can be steamed or fried prior to being served. Studies on the shelf-life of frozen prepared products are mostly carried out by the processing companies for thier quality control purposes. The results are rarely published, because companies want to keep them confidential. Recently, Labuza *et al.* (1992), Fu and Labuza (1993), and Kim (1992) reported shelf-life studies on chilled meat products, but there are few reports published in Korea on the shelf-life of precooked frozen foods.

Quality of frozen foods is significantly affected by the storage temperature, compared to that of processed foods stored at the ambient temperature, because the storage temperature as well as its fluctuation affect the rate of chemical and enzymatic reactions and changes in ice crystals. Currently, efforts on the product development of frozen foods are mostly focused on the cooked

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products, resulting in various frozen prepared foods available to the consumers. Therefore, more efforts on the shelf-life research of frozen foods are required to satisfy the consumers' demand for high quality foods.

The objective of this research was therefore to estimate the shelf life of frozen cooked meat dumplings, the most popular precooked frozen foods in Korea, based on the changes in the selected physico-chemical and sensory quality attributes.

Materials and Methods

Dumplings and storage conditions

Precooked frozen meat dumplings were sampled from the lot produced at a frozen foods company located in seoul, Korea. The samples were transported to the food processing laboratory of Chungang University by a refrigerated truck, and stored at –20°C until used for the storage tests. Dumplings were packaged in polyethylene bag, and stored at –10, –15 and, –20°C. Dumplings stored at –10°C were sampled at 3 week intervals, and those at –15 and –20°C at 4-week intervals. Samples were thawed in a cold room at 5°C for 15 hours, and used for the physico-chemical analysis and sensory evaluation. All storage tests were triplicated.

VBN, POV and TBA

VBN was analysed by the modified micro-diffusion assay (9). Ten grams of a stored sample with 50 mL water was blended (PT10-35, Polytlon, Switzerland) for 1 min., and filtered. Two mL of 0.01 N H_2SO_4 was added to the center compartment and 1 mL of filterate and saturated K_2CO_3 solution to the outer compartment of the Conway micro-diffusion unit. The filterate and K_2CO_3 solution were slowly shaked for 3 h at 37°C and titrated againt 0.01 N NaOH after adding a few drops of Burnswik reagent.

$$VBN\ (mg\%) = 0.14 \times (b-a) \times f / w \times 100 \times d$$

where, w : weight of sample
a : titer for a sample (mL)
f : factor of 0.01 N-NaOH
b : titer for blank (mL)
d : dilution factor

POV was determined using the AOCS method (A.O.C.S (1988)). Small quantity of Na_2SO_4 and 30 mL of chloroform-acetic acid (2 : 3, v/v) was added to the mixture of sample (5-10 g), and blended for 1 min. The mixture was centrifuged at 3000 rpm for 15 min. Saturated KI solution (0.5 mL) was added to the supernatant, sealed, and kept in a dark room for 15 min. After adding 30 mL of water and 1 mL of 1% starch solution, the mixture was titrated against 0.1 N $Na_2S_2O_3$. POV was expressed as meq peroxide per Kg of sample;

$$POV\ (meq/Kg) = N \times (a-b) / sample\ weight\ (Kg) \times 1000$$

where, N: concentration of Na_2S_2O
a : titer of sample (mL)
b : titer of blank (mL)

TBA values were determined using the method of Witte *et al.* (1970). Sample (20 g) was blendeded with 50 mL of 20% trichloroacetic acid in 2 M phosphoric acid into a total volume of 100 mL. Five mL of the supernatant, obtained after centrifuging the blended mixture, and 5 mL of 0.005 M thiobarbituric acid were mixed in a test tube (15×200 mm) and kept in a dark room for 15 h. The absorbance of the sample was measured at 530 nm (UV-visible spectrophotometer, GBC, 914, Australia), and TBA values were expressed as malonaldehyde mg/Kg.

Surface color and texture

Changes in surface color (L, a, and b) of stored samples were measured using a Color Difference Meter (Hunter Lab., CQ-1200x, USA). Total color difference (△E) was calculated using the equation $\triangle E = (\triangle a^2 + \triangle b^2 + \triangle c^2)^{1/2}$. L, a, and b values of the standard plate were 94.81, –0.96 and 0.43, respectively. Shear forces of samples were measured using the Texture test system (Food Technology Corporation, T2100C, USA) with a force transducer of 300 lbs. The cross head speed was set at 40 s/cycle, and a single blade cell was used for the shear force determination.

Sensory evaluation and statistical analysis

The triangle test (Kim, 1999) was used for the determination of high quality shelf-life of dumplings. Fifty panel members were trained three times to be familiarized with the triangle test and the sample before being selected for the triangle tests. Fourty selected members were employed for the triangle tests. A 7-point scoring test with 20 trained panel members was used for the determination of practical shelf life. Dumplings were heated for 1.5 min in a microwave oven before being served to the panel. All sensory tests were duplicated.

Statistical analysis system (SAS) was used for the statistical analysis of experimental data. Significant difference among the mean values was evaluted using Duncan's multiple range test ($p<0.05$). The significance of triangle test results was analyzed through Chi-square test.

RESULTS AND DISCUSSION

Changes in VBN, POV, and TBA

Changes in VBN contents during the frozen storage of meat dumplings are shown in Fig. 1. The initial VBN contents of dumplings was 3.13 mg%, indicating good quality. VBN contents of dumplings gradually increased, upto 10 mg%, with the extension of storage period. Temperature effect was not significant between -10 and −15°C.

Takasaka (1975) reported that VBN contents of fresh meat and spoiled products were 5-10 and 30-40 mg%, respectively, and Byun *et al.* (1985) suggested that meat products with over 18 mg% of VBN had noticeable off-flavor and abnormal appearance. Frozen dumplingss stored at all temperatures in this experiment did not exceed 10 mg% of VBN after 36 weeks storage. This could be due to the effect of polyethylene film packaging, which limited moisture and gas permeation to some extent during frozen storage (Brewer, 1992).

Lipid oxidation is one of the main causes of quality loss in meat products during storage (Harel, 1985). Changes in POV of meat dumplings during frozen storage are shown in Fig. 2. The initial POV of frozen dumplings was 0.63 meq/Kg and increased upto 2.83 meq/Kg at −10°C, as the storage period was extended to 36 weeks. Temperature effect on the increase of POV was not significant ($p>0.05$).

TBA value is often used as an index of lipid oxidation in meat products during storage. The initial TBA value of meat dumplings was 0.13 (MA mg/Kg) and did not increased significantly after 36 weeks storage at −10, −15, and −20°C, respectively (Fig. 3). Temperature effect

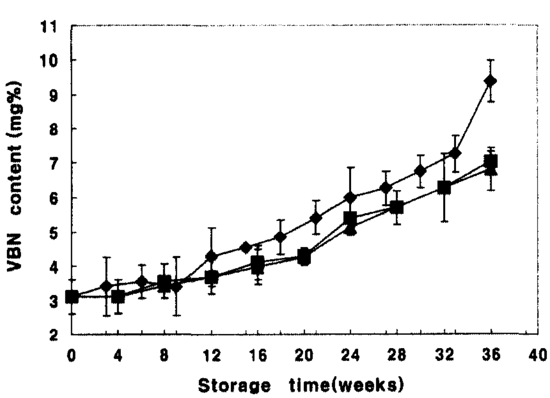

Fig. 1. Changes of VBN content in meat dumpling during storage at various temperatures (◆-◆ : −10°C, ■-■ : −15°C, ▲-▲ : −20°C)

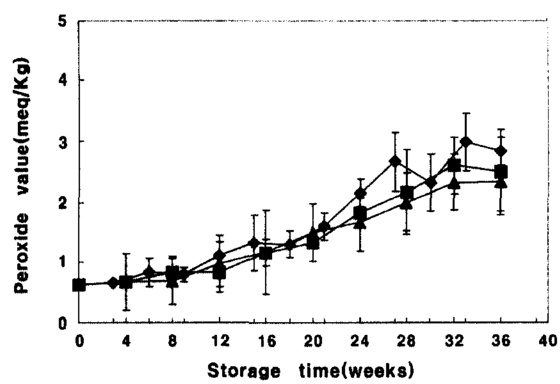

Fig. 2. Changes of POV values in meat dumpling during storage at various temperatures (◆-◆ : −10°C, ■-■ : -15°C, ▲-▲ : −20°C).

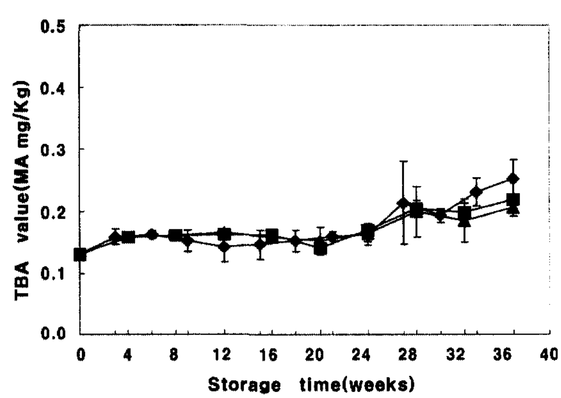

Fig. 3. Changes of TBA values in meat dumpling during storage at various temperatures (◆-◆ : −10°C, ■-■ : −15°C, ▲-▲ : −20°C).

on the changes in TBA value during the storage was not significant (p>0.05), in agreement with the report of Wu *et al.* (1991) which revealed that TBA values in the fermented mutton sausages stored at 2 and 20°C were not markedly different. Turner *et al.* (1954) indicated that there was a close relationship between TAB values and sensory scores of meat products. TBA values of high quality meat products and spoiled ones were less than 0.46 (MA mg/Kg) and over 1.2 MA mg/Kg), respectively.

Surface color and shear value

Changes in total color difference △E of meat dumplings during frozen storage are summarized in

Table 1. Changes in Hunter values of precooked frozen meat dumplings during storage

	−10°C			−15°C			−20°C		
E	Storage time	L	△E	Storage time	L	△E	Storage time	L	△E
	0 weeks	71.1		0 weeks	71.1		0 weeks	71.1	
	3	71.4	0.80	4	72.5	1.53	4	72.3	1.72
	6	71.3	0.46	8	71.3	1.18	8	1.9	1.88
	9	70.6	1.27	12	72.8	2.50	12	72.9	2.33
	12	71.7	1.49	16	72.3	1.75	16	72.5	2.28
	15	73.4	3.43	20	72.3	1.77	20	72.5	2.44
	18	72.7	2.69	24	74.9	4.14	24	72.9	2.51
	21	74.2	3.82	28	74.4	3.54	28	72.9	2.96
	24	74.7	3.89	32	74.4	3.91	32	73.0	2.94
	27	75.5	4.57	36	75.2	4.60	36	74.2	4.04
	30	75.7	4.85						
	33	75.5	4.87						
	36	75.8	5.16						

Table 2. Changes in shear force (lbs) of precooked frozen meat dumplings during storage

−10°C		−15°C		−20°C	
Storage time	Shear force	Storage time	Shear force	Storage time	Shear force
0	3.9±0.98b	0	3.9±0.98c	0	3.9±0.98b
3	4.2±1.20b	4	3.5±0.95c	4	3.5±0.79b
6	4.1±0.78b	8	4.1±1.02c	8	3.4±1.09b
9	2.5±0.78b	12	5.1±1.11cb	12	4.3±0.84bc
12	4.8±1.03b	16	5.1±0.54cb	16	4.6±1.63b
15	4.7±0.87bc	20	6.2±0.57ab	20	7.2±0.98a
18	5.9±0.85abc	24	6.5±0.65ab	24	6.8±0.47a
21	7.1±1.31ab	28	7.1±1.30ab	28	7.3±1.16a
24	7.3±1.42ab	32	7.5±1.14a	32	7.6±1.12a
27	7.5±1.44a	36	7.6±1.29a	36	7.8±1.41a
30	7.3±0.83a				
33	7.8±1.16a				
36	8.0±1.19a				

Note: Means of 6 replications with the same letter in the same column are not significantly different (p<0.05).

Table 3. Correct reponses in triangle tests of precooked frozen meat dumplings during storage

−10°C		−15°C		−20°C	
Storage time	Responses	Storage time	Responses	Storage time	Responses
3 weeks	6/18	4 weeks	10/20	4 weeks	6/20
6	8/20	8	5/20	8	7/20
9	10/20	12	9/20	12	10/20
12	7/20	16	8/20	16	8/20
15	9/20	20	5/20	20	8/20
18	10/20	24	7/20	24	9/20
21	9/20	28	8/20	28	10/20
24	6/20	32	9/19	32	8/19
27	12/20*	36	15/20*	36	10/20
30	11/20*				
33	9/29				
36	16/20*				

Note; Responses with * symbol are significantly different ($p<0.05$, χ^2-test).

Table 1. △E values of the meat dumplings increased as the storage time was extended. The increase was less at -20°C, compared to that at −10 or −15°C, but temperature effect on the increase in △E was not significant. Hunter L values decreased during storage, indicating the darkening of the product, and resulted mostly in the increase of △E. Jeremiash (1982) studied the color change of pork chops packed in polyethylene or aluminium foil bags and stored at -30°C, and found that the darkening of pork chops was the most significant changes in color.

Shear values of the frozen meat dumplings were significantly increased after 12, weeks at −10 and −15°C and after 20 weeks of storage at -20°C (Table 2). However, the temperature effect on the changes in shear values was not significant.

High quality life(HQL) and practical quality life(PQL)

HQL is the storage period during which 70% of panelists ($p<0.05$) through triangle test can not detect the quality difference between control and the sample stored at a selected temperature (Matlock, 1984). The results of triangle tests on the stored pork cutlets (Table 3) revealed that significant quality differences ($p<0.05$) were detected after 27 and 36 weeks storage at −10 and −15°C, respectively. Therefore, the HQL of the precooked meat dumplings were determined to be 189 and 252 days at −10 and −15, respectively. The storage period of 36 weeks was not long enough to determine HQL of meat dumplings at -20°C.

PQL is the maximum time the product can be stored at a given temperature and still be fully acceptable to the consumer (Lief, 1984). In this scoring test, the lower limit score for PQL was set at 4.0. The results of Table 4 show that the sensory scores of the meat dumplings stored at −10, −15 and -20°C were higher than 4.0 after 36 weeks storage. Therefore, PQL of the pork cutlets could not be determined directly from the sensory test results. The relationships between sensory scores and the storage time at the three temperatures were nonlinear. Data collected by Jul (1984) showed that ground pork with iodine numbes of 68.4 and 58.8 packaged in waxed paper had PQL of 240 and 400 days at −18°C, respectively, indicating that PQL of pork products were significantly affected by the unsaturated fat contents.

Quality index for the shelf-life determination

The relationships between the results of sensory scores and physico-chemical quality attributes of pork cutlets determined in this study were evaluated to determine a suitable physico-chemical quality index for the shelf-life determination. The results of Table 5 showed that VBN, POV and moisture contents had

Table 4. Scoring tests of precooked frozen meat dumplings during storage

−10°C		−15°C		−20°C	
Storage time	Scores	Storage time	Scores	Storage time	Scores
0 weeks	6.2±0.46a	0 weeks	6.2±0.46a	0 weeks	6.2±0.46a
3	6.1±0.49ab	4	6.0±0.82ab	4	6.1±1.14a
6	5.9±0.90abc	8	5.9±0.73ab	8	5.8±0.79abc
9	5.6±1.09abcd	12	5.9±1.14ab	12	5.8±1.05abc
12	5.8±0.89abcd	16	5.8±1.25ab	16	5.6±0.76abc
15	5.6±0.85abcd	20	5.6±1.28ab	20	5.6±0.84abc
18	5.5±1.09bcde	24	5.6±0.52ab	24	5.4±0.65bcd
21	5.4±1.23bcde	28	5.2±0.89ab	28	5.2±1.05cd
24	5.2±1.23bcde	32	5.4±0.84b	32	5.1±0.92d
27	5.3±1.29cde	36	5.1±0.92b	36	5.1±0.77cd
30	5.0±1.21de				
33	4.8±1.27e				
36	4.8±0.97e				

Note: Means with the same letter in the same column are not significantly different (p<0.05).

Table 5. Correlationships among the sensory score and physico-chemical values of pre-cooked frozen meat dumplings during storage at −10, −15 and -20°C

Sample	Measurement	Regression equation	Correlation Coefficient (R)
−10°C	VBN	Y=−3.7727X+25.824	−0.947*
	TBA	Y=−0.0694X+0.5523	−0.843
	POV	Y=−1.7865X+11.374	−0.935*
	Shear force	Y=−3.1258X+22.797	−0.8386
−15°C	VBN	Y=−3.7085X+25.593	−0.953*
	TBA	Y=−0.0701X+0.5669	−0.8691
	POV	Y=−2.0222X+12.880	−0.941*
	Shear force	Y=−3.6725X+26.536	−0.8966
−20°C	VBN	Y=−3.3910X+23.518	−0.965*
	TBA	Y=−0.0519X+0.4580	−0.853
	POV	Y=−1.7093X+10.951	−0.956*
	Shear force	Y=−4.2440X+29.362	−0.8782

Y: variable, X : sensory score.
Correletion coefficients with subscript(R*) are significant at 5% level.

significant linear relationships with the sensory scores (p<0.05). As the correlation coefficient of sensory scores were higher between VBN values, VBN was selected as the quality index of precooked meat dumplings for the shelf-life determination.

The VBN values corresponding to the limiting sensory score (4.0) of PQL, estimated from the linear regression equations of Table 5, were 10.73, 10.76 and 9.95 meg% (average 10.48 mg%) at −10, −15, and −20°C, respectively.

The regression equations between the storage time and VBN of meat dumplings are shown in Table 6. PQL corresponding to VBN of 10.48 mg%, estimated from the regression equations, were 349, 475 and 491 days at −10, −15, and −20°C, respectively. Kim (1999) reported

Table 6. Regression equations for PQL estimation of meat dumplings stored at 3 different temperatures

Sample	Storage temperature	Regression equation	Correlation Coefficient (R)
Meat dumplings	−10°C	Y=42.588X−97.430	0.966*
	−15°C	Y=59.720X−150.81	0.967*
	−20°C	Y=61.562X−154.43	0.983*

Y: Storage time(days), X: VBN content.
Correletion coefficients with subscript (R*) are significant at 5% level.

that the upper limit of VBN value for the PQL of pork was 11.4 mg%, which was in close agreement with our results.

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