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Effect of Muscle Types of Bali Beef Pre and Post Rigor on the Quality of Meatballs During Storage

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Abstract: Liquid smoke besides has been recognized to have the function for specific taste and aroma; it also serves as a preservative for antimicrobial and antioxidant properties. Utilization of liquid smoke as a natural preservative and to friendly environment has been much conducted in the preservation of fish, however, to our knowledge, very little information is available on the use of liquid smoke in the meat products. The aim of this study was to characterize the quality of meatballs originated from Bali beef that added with 1% of liquid smoke based on the meat weight. The experimental design was completely reandomized in a factorila arrangement 3 x 2 x 4. Factor 1 was the type of muscle (*Longissimus dorsi*, *semitendinosus*, *Pectoralis profundus*), factor 2 was rigor phases (pre and post-rigor) and factor 3 was storage duration (up to first week, week-2, week-3 and week-4) with 5 replications. The variables measured were shear force of meatballs, meatballs flexibility, quality assessment of sensory panelists (firmness, tenderness and flavor) and the level of panelists' preference. The results of this study showed that the addition of liquid smoke 1% of the meat weight (w/w) produced a high quality meatballs indicated with a shear force, flexibility and similarity in sensory qualities in all three phases of muscle from different rigor. The longer duration increased shear force, while flexibility and sensory quality were decreased. It can be concluded that 1% of liquid smoke was able to maintain characteristics of meatballs quality for two weeks.

Key words: Liquid smoke, preservative, meat balls, sensory quality, Bali beef

INTRODUCTION

One of processed meat products that are greatly favored by the people, especially in Indonesia is the meatballs. Increased demand for qualified meatballs (chewy), compact, solid and durable making the most of meatball sellers have to add a few extra ingredients instead of meat. The addition of borax and formaldehyde in the dough balls are meant to produce a chewy meatball and durable, however it is the risk to the health.

Efforts to improve the functional properties of the processed products have been carried out through the addition of additives in order to increase the water binding capacity of meat (water holding capacity). For example, the addition of sodium tripolyphosphate (Abustam and Ali, 2004; Syaputra, 2009), sodium diphosphate (Amang, 2006; Mutmainnah, 2006), or by using a meat with high water holding capacity on condition pre-rigor (Rahayu, 2006). Likewise, liquid smoke has also been used to improve or preserve food materials such as fish.

Liquid smoke is the result of condensation of the pyrolysis of wood or coconut shells through heating at a temperature of 400-600°C in a tube or drum. Liquid smoke contains more than 400 chemical compounds such as phenols (4.13%), carbonyl (11.3%) and acid (10.2%) (Setiadji, 2000). The compounds contained in liquid smoke can act as a preservative and emulsifier (Cahyadi, 2006). The addition of liquid smoke on meat pre-rigor able to maintain or improve the functional properties of fresh meat, then limited processing time can be extended (Abustam and Ali, 2012), improving the quality of cooking meatballs that decreased shrinkage, increased tenderness, increased resilience and increased the level of preference (Abustam *et al*., 2009; Abustam *et al*., 2010).

Liquid smoke in addition to functioning as the taste and aroma specific can also acts as a preservative for antimicrobial and antioxidant properties. Utilization of liquid smoke as a natural preservative and environmentally friendly have been carried out on fish preservation but to our knowledge, it is still very little information on its use in processed meat products especially the use of Bali beef for making meatballs. Therefore, the aim of this study was to characterize the qualitative properties of Bali beef meatballs after treated with liquid smoke.

MATERIALS AND METHODS

Types of meat and composition of meatballs: Three types of muscle pre and post-rigor; longissimus dorsi (LD), semitendinosus (ST) and pectoralis profundus (PP) of Bali cattle aged 3 years, that represent to the

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Table 1: Materials and composition of meatball used in the study

Material	Composition	Ratio to the meat used (%)
Meat	300	100
Wheat flour	90	30
Ice	60	20
Salt	9	3
Pepper	3	1
Garlic	12	4
Liquid smoke	3	1

tender, medium and less tender, respectively as the main ingredient of the meatballs were used in the study. Additional ingredients were flour starch as a filler and liquid smoke as a binder and preservatives. Other materials required in making meatballs such as salt, ice and flavoring ingredients (pepper, garlic) were also used in the study. The compositions of the meatballs are shown in Table 1.

Experimental design: This study was arranged based on Completely Randomized Design (CRD) with 2 x 3 x 4 with 5 replications. The first factor was the status of rigor; pre-rigor and post-rigor. The second factor was the type of muscle; Longissimus dorsi, Semitendinosus and Pectoralis profundus. The third factor was storage duration; 1, 2, 3 and 4 weeks. Level of liquid smoke added to the dough was 1% of the liquid smoke that has been diluted to a concentration of 10%. The parameters measured were the shear force of meatballs, meatballs resilience, sensory quality (firmness, tenderness and flavor) and the level of preference panelists (hedonic).

Tenderness: Tenderness was measure using a CD Shear Force. The meat samples were form in cylinder with a length of 1 cm and a diameter of 0.5 inches. The meat was placed in the hole of CD shear force using the knife to cut a 1 mm thick sample. The larger of the sample load to break the meat then the meat tough. The values expressed in kg/cm^2 (Abustam *et al*., 1993).

Resilience: Resilience measurement was performed by dropping the meatballs at a height of 50 cm by 5 different pieces of meatballs in a cylinder scale glass. High reflectance of each meatball converted into 4 scores (1 to 4) with the initial advance for the difference between the highest to lowest reflectance and then divided by 4 to get the interval between each score. Score 1 was less resilience and a score of 4 was having best resilience (Abustam *et al*., 2009).

Sensory quality test and levels of meatballs preference: A sensory test and preference of meatballs were conducted using 15 panelists who previously have undergone to a special training. To assess the meatballs, they were using a swinging assessment scoring of 1-6 on tenderness, firmness and flavor, where score 1: very tough, very chewy, intensity flavor very weak and score 6: very tender, very chewy, very strong flavor intensity (Abustam *et al*., 2009). Hedonic test was performed by panelists using a score of 1-6, where: 1. really do not like, 2. a bit like, 3. not like, 4. like, 5. a little like and 6. really like.

Statistical analyses: Data were analyzed using factorial analysis of variance to determine the effect of treatment on the three factors; shear force, meatballs resilience, sensory quality (firmness, tenderness and flavor) and the level of preference of meatballs after treated with liquid smoke (Steel and Torrie, 1991).

RESULTS AND DISCUSSION

Shear force of meatballs: Muscle types and rigor phases had not affecting the meatballs shear force value, however storage duration had significant ($p<0.01$) effect to shear force value. Differences in muscle tenderness in a fresh state seemed to be approximately similar when made into liquid smoke meatballs. This suggests that the addition of liquid smoke 1% of the weight of the meat was able to eliminate the differences in tenderness. Similarly, muscle tenderness differences due to the different conditions of rigor, which in general was not soft as pre-rigor muscles with muscle post-rigor be more or less equal of the shear force value when made into meatballs with the addition of liquid smoke 1%.

By increasing the storage duration, the meatballs of liquid smoke 1% had lower or more tender. During the 4 weeks of storage, improvement of tenderness was 61.30% from 0 week of storage. Improvement of fresh meat tenderness during cold storage (2-5°C) was generally caused by proteolytic enzymes known as the maturation process (aging), but the rate of improvement during 4 weeks of storage was not as big as those found in liquid smoke meatballs in this study. Our previous study on fresh meat showed that the addition of liquid smoke at 1.0 and 1.5%, respectively resulting in improvement of tenderness 4.74 and 6.92%, respectively during 8 h of storage (Abustam and Ali, 2010). This indicated that the addition of liquid smoke as an antioxidant and antimicrobial material can also serve as a tenderizer.

Resilience: Muscle types and rigor phases did not significantly affect the meatball resilience. However, storage duration was significantly ($p<0.05$) affecting the resilience of meatballs liquid smoke 1%. Resilience meatballs liquid smoke 1% in muscle and rigor of different phases were relatively similar. This indicated that the differences in the functional properties of fresh meat were relatively similar when it processed as meatballs using liquid smoke of 1%. Previous study showed that the level up to 1% of liquid smoke could increase the resilience of the meatballs as a result of a decline in cooking shrinkage (Abustam *et al*., 2009).

Table 2: Mean of the parameters and level of significance

Treatment	Shear force (kg/cm^2)	Resilience* (score)	Elasticity** (score)	Tenderness** (score)	Flavor** (score)	Hedonic*** (score)
	---------- Significance of the mean variables observed ----------					
Muscles type:	Sig: 0.98	Sig: 0.56	Sig: 0.46	Sig: 0.01	Sig: 0.96	Sig: 0.92
LD	1.49	2.6	3.37	3.71^a	2.98	2.93
ST	1.51	2.58	3.29	3.68^a	2.95	2.89
PP	1.51	2.65	3.22	3.38^b	3	2.86
Rigor phase:	Sig: 0.18	Sig: 0.14	Sig: 0.27	Sig: 0.88	Sig: 0.64	Sig: 0.94
Pre-rigor	1.56	2.57	3.35	3.59	3.01	2.9
Post-rigor	1.45	2.65	3.24	3.58	2.94	2.89
Storage duration:	Sig: 0.00	Sig: 0.07	Sig: 0.00	Sig: 0.00	Sig: 0.00	Sig: 0.00
1 week	2.30^a	2.73^a	4.27^a	4.50^a	4.27^a	4.04^a
2 week	1.57^b	2.64^{ab}	3.48^b	4.14^b	3.38^b	3.21^b
3 week	1.28^c	2.57^{bc}	2.13^c	2.12^c	1.28^c	1.44^c
4 week	0.89^d	2.49^{cd}	-	-	-	-

^{a,b,c,d}Values in a column with different superscripts differ significantly ($p<0.05$)

*Score for resilience of meatball: 1-4 (1: poor-4: finest)

**Score for elasticity, tenderness, flavor: 1-6

1: very tough, very chewy, intensity flavor very weak and score 6: very tender, very chewy, very strong flavor intensity)

***Score for hedonic: 1-6 (1:strongly do not like-6: strongly like)

The longer storage, resilience was decreased where there was a significant different between week-1 to week-3 and week-4. This suggests that 1% liquid smoke meatballs could maintain resilience until the 2nd week of storage.

Elasticity (panelist scoring): Muscle types and rigor phases did not affecting the elasticity of the meatballs. However, based on the panelist scoring, storage duration was significantly ($p<0.01$) affecting the elasticity of the liquid smoke meatballs 1%. Both types of muscle and rigor phases resulted elasticity score roughly similar on the meatballs liquid smoke 1%, although there was a tendency soft muscles (Longissimus dorsi) have a little springiness scores better than medium muscle (semitendinosus) and less tender muscle (Pectoralis profundus). Similarly pre-rigor phase scores were slightly better than phase post-rigor. Very little difference in scores between the muscle and the rigor phase, indicating that the addition of liquid smoke 1% in making Bali beef meatballs was able to provide the same elasticity based on the type of muscle and rigor phases. The longer of the storage duration decreased elasticity score at week-3 where the elasticity score decreased to 50.12% of the score to 1 week.

Sensory tenderness (Panelist scoring): Rigor phases had no effect on sensory tenderness. However, muscle type and storage duration were significantly ($p<0.01$) affecting the sensory tenderness score assessed by panelists. The third characteristic of muscle tenderness in the fresh state providing sensory tenderness scores meatballs liquid smoke 1% in the same direction in which the meatballs tenderness scores of Longissimus dorsi better than semitendinosus and the Pectoralis profundus, likewise, semitendinosus as well as meatballs better than meatballs Pectoralis profundus. Longer storage duration, the tenderness scores were decreased, which in week-3, panel tenderness scores decreased to 52.89% from the first week.

Flavor: Muscle types and rigor phases did not affect the flavor. Storage duration was significantly ($p<0.01$) affecting the flavor of meatballs liquid smoke. Addition 1% of liquid smoke resulted in flavor of in three different muscles was relatively similar. Longer the storage duration decreased the flavor of the meatballs which flavor score to 70.02% from the first week of storage.

Hedonic: Muscle type and rigor phases had no effect on hedonic, while storage duration was significantly ($p<0.01$) affecting the hedonic score. Panelists' preferences on meatballs liquid smoke 1% at different muscle types and the rigor phases were relatively similar. This indicated that liquid smoke, in which added to the meatballs from different muscle types and rigor phases produced meatballs with the same level of preference panelists. Longer of storage duration resulted panelist preference level was decreased, whereas in the third week of a 64.36% preference level in comparison to the first week.

Conclusion: The addition of liquid smoke 1% in making meatballs from three types of muscles and different rigor phases produced high quality of meatballs. This characterized by shear force meatballs, resilience and sensory quality that relatively similar in three different rigor phases and muscles.

The longer storage duration, the meatballs shear force, resilience and sensory quality was decreased. Decrease in sensory quality during storage was linearly with the decreased the level of preference. Storage until the week-2 could be considered to maintain sensory quality of liquid smoke 1% meatballs.

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