The Pharma Innovation Journal 2023; 12(5): 1684-1686

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 1684-1686

www.thepharmajournal.com
Received: 09-02-2023
Accepted: 15-04-2023

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Texture profile analysis of low-fat smoked buffalo meat sausages

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Abstract
Buffalo meat sausages were developed employing different smoking methods and fat levels to obtain a healthy product with extended shelf-life and economic feasibility. Three primary treatment groups were prepared, namely- T1 (20% fat), T2 (10% fat + 10% inulin), T3 (7.5% fat + 12.5% inulin), which were divided into three subgroups, A (Conventional smoking), B (3% Liquid smoke), C (7% Liquid smoke). The control was prepared with 20% fat without any sub-treatments. 5 batches of buffalo meat sausages were prepared, and the texture profile analysis was evaluated. The TPA results showed that with higher inclusion of inulin as a fat replacer, the hardness, springiness, chewiness and resilience significantly increased. However, smoking methods did not significantly affect the TPA.

Keywords: Texture, low-fat, buffalo, meat, sausages

Introduction
Meat is the most important nutritious food item in the non-vegetarian diet. Because of their nutritional richness, meat products are essential to a healthy, well-balanced diet. They are rich in proteins and micronutrients, including iron, selenium, zinc and vitamin B12 (Zhuang *et al.*, 2015) [13].

Carabeef possesses good binding properties and is functional in product making. It has been used in the production of several value-added meat products, *viz*. sausages, meat loaves, burger patties, corned buffalo meat, and cured and smoked products (Anjaneyulu *et al.*, 2007) [3]. Sausages are a favoured meat product and are usually prepared from ground beef, pork and poultry, along with salt, spices, condiments and other ingredients stuffed into casings. There are different varieties of sausages, such as cooked sausages, cooked smoked sausages, dry sausages, fermented sausages, uncooked smoked sausages etc. Various cooking methods applied while preparing a product, such as boiling, grilling, frying, curing, drying, smoking, etc., improve the product's shelf life and enhance taste and flavour. According to a study by Juarez *et al.* (2009) [7], frying has been reported as the worst cooking method against boiling and grilling concerning human health due to the production of the highest levels of harmful trans fatty acids.

The fat in meat products affects its sensory properties, gives the desirable appearance, deliciousness, and texture acceptability, plays a significant role in forming a creamy state, and imparts a feeling of satiety. However, the increased incidences of cardiovascular diseases resulting from high dietary intake of saturated fats and cholesterol have made consumers conscious (Mohammad *et al.*, 2009) [10]. Based on Purcaro *et al.* (2013) [11], fat is the major precursor of PAH formation, where the amount of fat in processed food affects the PAH level.

Materials and Methods
The buffalo meat and fat procured from the local market were brought to the laboratory of the Department of Livestock Products Technology, College of Veterinary Science, Khanapara. Subsequently, meat was trimmed and deboned, cut into chunks stored in a deep freezer maintained at -18 °C until use.

Cellulose casing (21 mm) diameter was used for stuffing the buffalo meat emulsion. Liquid smoke SMOKEZ ENVIRO 24PB (Make: Red Arrow International, Manitowoc, USA) obtained from Indi-Pure Resources LLP, Ahmedabad, was utilised in this study. The liquid smoke was diluted in a ratio of 1:4 and added at 3% and 7%. Inulin (Make: Urban Platter) was purchased through Amazon. Best-quality spices, binders and condiments were obtained from the local market. All the ingredients were added to the meat emulsion as per specified quantities.

For the preparation of buffalo meat sausage, the following recipe was used: Lean buffalo meat- 80%, Buffalo fat-20% (control and T1), 10% (T2) and 7.5% (T3), Inulin-0% (control and T1), 10% (T2) and 12.5% (T3), spices-1.5%, condiments-3%, binder-3%, ice flakes-10%, sugar- 0.5%, salt-2.3%, sodium nitrite- 0.15%, STPP-0.5%, ascorbic acid-0.2%.

The frozen lean buffalo meat and fat were thawed overnight at 4 ± 1℃ and then minced in a mechanical meat mincer. The minced meat was added to the curing agent and rested for 24 hrs. The cured meat was later transferred into a bowl chopper, whereby other ingredients of the recipe, *viz*, fat, inulin, spices, condiments, and non-meat ingredients, were added to form an emulsion. After mixing the liquid smoke at the mentioned percentage, the emulsion was stuffed into the casing. The raw sausages were cooked at 85 ℃ for 45 minutes in a cooking vat. Immediately after cooking, the sausages were immersed in ice-cold water to neutralise the latent heat, and the excess water was drained off. The conventional smoke treatments were then

exposed to hot smoking at 60 ℃ for 40 minutes. The casings were peeled off, packed in vacuum packages and kept in refrigeration storage. The resultant emulsion was divided into 10 parts, *viz*.

Control (C)	Sausage with 20% added fat without any smoke treatment
T1A	Sausage with 20% added fat and conventional smoking
T1B	Sausage with 20% added fat and 3% liquid smoke
T1C	Sausage with 20% added fat and 7% liquid smoke
T2A	Sausage with 10% added fat, 10% inulin and conventional smoking
T2B	Sausage with 10% added fat, 10% inulin and 3% liquid smoke
T2C	Sausage with 10% added fat, 10% inulin and 7% liquid smoke
T3A	Sausage with 7.5% added fat, 12.5% inulin and conventional smoking
T3B	Sausage with 7.5% added fat, 12.5% inulin and 3% liquid smoke
T3C	Sausage with 7.5% added fat, 12.5% inulin and 7% liquid smoke.

Texture Profile Analysis

The texture profile of the buffalo meat sausage samples was analysed using the Texture Analyzer (Make: Stable Micro Systems, Model: TA-HD plus). The sample with a homogenous size of 3 mm was positioned on the platform and compressed by 50%. During this process, compression was done twice, with the pre-test speed being 1 mm/sec, the test speed being 2.0 mm/sec, and the post-test speed being 10.0 mm/sec. An aluminium cylindrical probe (SMS P/36R of 75 mm diameter) and a 500 kg load cell with a load range of 0-500 kg at the crosshead were used to perform the test. The distance kept between the probe and the sample was 5 cm.

Textural attributes such as Hardness, Springiness, Cohesiveness, Chewiness and Resilience were analysed.

Result and Discussion

The results of the texture profile analysis, presented in Table1, show significant differences ($p<0.05$) in the values of hardness, springiness and resilience between the control and treatment groups T2 (10% fat + 10% inulin) and T3 (7.5% fat + 12.5% inulin). However, there was no significant difference among subgroups A, B and C. The increased hardness, springiness and resilience of the treated products could be attributed to the ability of inulin to assist and build connections between the various matrix components (Cruz *et al*., 2010) [4]. It might also be because of the physically harder nature of inulin crystals (Keenan *et al*., 2014) [8].

Gracia *et al*. (2006) [6] reported that 7.5% of inulin sausages were significantly harder than the control in conventional and reduced-fat sausages. The results of the present study agree with that of Menegas *et al*. (2013) [9] and Alvares and Barbut (2013) [2]. Likewise, Keenan *et al*. (2014) [8] observed that the hardness values ranged from 39.8 N (full-fat controls) to 126.1 N (full-inulin substitution) in comminuted meat products. Similarly, Alaei *et al*. (2017) [1] and Gadekar *et al*. (2017) [5] reported an increase in the springiness and resilience values of chicken sausages with 25% inulin substitution, and in restructured goat meat than those containing chitosan and carrageenan, respectively.

The results for cohesiveness and chewiness showed a significant difference between the treatment group T3 and the control. The results of the present study were in accordance with Verma *et al*. (2015) [12] and Gadekar *et al*. (2017) [5]. They found that cohesiveness value increased with increasing levels of sweet potato powder (SPP) in low-fat pork patties and restructured goat meat products, respectively.

According to Menegas *et al*. (2013) [9], the addition of inulin to semi-dry fermented chicken sausage resulted in considerably increased chewiness ($p<0.05$) than the formulation with lower oil content. Likewise, Keenan *et al*. (2014) [8] and Verma *et al*. (2015) [12] observed an increasing trend for chewiness values for inulin-substituted comminuted meat and sweet potato powder (SPP) in low-fat pork patties.

Table 1: Texture profile analysis of buffalo meat sausages with different methods of smoking and levels of fat (mean ± se)

Parameters	Hardness	Springiness	Cohesiveness	Chewiness	Resilience
Control	3.77 ± 0.52a	0.82 ± 0.01a	0.43 ± 0.05a	1.44 ± 0.43a	0.24 ± 0.04a
T1A	3.84 ± 0.51ab	0.84 ± 0.02ab	0.46 ± 0.06ab	1.61 ± 0.50ab	0.25 ± 0.04ab
T1B	3.80 ± 0.41abc	0.84 ± 0.01abc	0.47 ± 0.05abc	1.61 ± 0.41abc	0.25 ± 0.03abc
T1C	3.76 ± 0.43abcd	0.84 ± 0.02abcd	0.47 ± 0.06abcd	1.59 ± 0.44abcd	0.25 ± 0.03abcd
T2A	5.70 ± 0.41e	0.88 ± 0.02e	0.56 ± 0.04abcde	2.85 ± 0.47bcde	0.37 ± 0.03e
T2B	5.42 ± 0.41ef	0.90 ± 0.01ef	0.56 ± 0.03abcdef	2.75 ± 0.41abcdef	0.35 ± 0.02ef
T2C	5.61 ± 0.44efg	0.90 ± 0.01efg	0.56 ± 0.04abcdefg	2.85 ± 0.46bcdefg	0.35 ± 0.04efg
T3A	7.77 ± 0.48h	0.97 ± 0.01h	0.67 ± 0.03efgh	5.09 ± 0.52h	0.52 ± 0.03h
T3B	7.77 ± 0.41hi	0.98 ± 0.01hi	0.68 ± 0.04efghi	5.22 ± 0.48hi	0.52 ± 0.02hi
T3C	7.56 ± 0.52hij	0.96 ± 0.01hij	0.65 ± 0.04efghij	4.76 ± 0.52hij	0.50 ± 0.03hij

n=5, Means with superscript bearing different alphabet (small) column-wise differ significantly ($p<0.05$)

Conclusion

From the present study, it has been found that with the addition of 12.5% inulin (i.e. 62.5% fat replacement with inulin) the product was significantly harder. Further, the effect of conventional smoking was not significant in the hardness of the treated products. Therefore, it can be concluded that 50% fat replacement with inulin can be used to prepare buffalo meat sausages without hampering the sensory attributes.

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