Turkish Journal of Veterinary and Animal Sciences

http://journals.tubitak.gov.tr/veterinary/

Research Article

Turk J Vet Anim Sci
(2015) 39: 364-368

doi:10.3906/vet-1307-38

Textural acceptability of prepared fish sausages by controlling textural indicators

Mehmet Tolga DİNÇER*, **Şükran ÇAKLI**
Department of Fishing and Seafood Processing, Faculty of Fisheries, Ege University, İzmir, Turkey

Received: 16.07.2013 • **Accepted/Published Online:** 27.02.2015 • **Printed:** 10.06.2015

Abstract: The purpose of this paper is to verify the textural quality and acceptability of two different prepared emulsion-type fish sausages that were evaluated by using rainbow trout (*Oncorhynchus mykiss*) and saithe (*Pollachius virens*) fillets. Texture properties of the fish sausages were compared with three different emulsion-type sausages (chicken, turkey, and beef sausages) using texture profile analysis (TPA), shear test, Kramer shear test, pate penetration test, cooking loss, and expressible moisture. According to the TPA and firmness values, some textural indicators were found significantly weak ($P < 0.05$), but they met consumers preferences.

Key words: Fish sausage, hardness, firmness, texture, meat sausage

1. Introduction

An emulsion-type sausage is processed by comminuting and emulsifying methods (1). Different types of sausages can be produced using beef, chicken, and turkey meat parts. Combinations of proteins from these meat parts can be used to produce emulsion sausages. In 2013, marketing products that are mixtures of different meat parts was forbidden due to the latest regulations of the Ministry of Food, Agriculture, and Livestock in Turkey. However, these types of emulsion sausages are still available in marketplaces. An emulsion sausage is a mixture of meat, processed meat wastes, water, fat, soy flour, starch, and spices. The moderate denaturalization of muscle proteins during the thermal process gives a fine texture and flavor to emulsion-type sausage. The texture and flavor of emulsion-type sausages are vital for meeting consumers' requirements. In Turkey, consumers prefer purchasing emulsion sausage with distinctive textural and color ranges from the refrigerated shelves of marketplaces. Many sausages produced in Turkey are red in color with certain textural properties due to customer preferences. Many studies were published comparing the texture and mechanical properties of emulsified sausages (2,3). Nevertheless, the literature about the emulsion-type fish sausage (4) is insufficient. Fish sausages can be produced by certain methods used for processing meat sausages. A mixture of fish flesh, farinaceous filler, flavorings, and additives is stuffed into a casing. Fish sausages have about 42 days of shelf life at refrigerated temperatures when a double pasteurization technique is used, with lower values of preservatives (5). In many countries, only a very short list of preservatives is permitted for use in fishery products. Fish sausages can be successfully stored as refrigerated products with good manufacturing practices as required for processing meat sausages. For consumers, the overall quality of an emulsion sausage includes acceptability of mechanical properties and appearance (6). Appearance is affected by the extent of packaging, color additives, and sensory properties, which are determined by flavor and texture in the emulsion sausage (7). Textural properties are changed by biochemical degradation due to the storage time and farinaceous filler content, which often leads to softening over time. Texture is a vital sensory characteristic that determines the quality and acceptability of a fishery product (8). A positive relationship between the texture and acceptance of the sausage products was observed after the texture test. The goal of this study was to determine the textural differences between emulsion-type beef, turkey, and chicken sausages and two types of fish sausages. Evaluation and development of new and alternative seafood products carry great importance for the Turkish seafood industry. This study was designed to make a textural comparison between new seafood emulsion products and current emulsion products in the marketplace.

2. Materials and methods

2.1. Sausage materials

Frozen and skinless rainbow trout (*Oncorhynchus mykiss*) and saithe (*Pollachius virens*) fillets were used as raw

* Correspondence: tolga.dincer@ege.edu.tr

materials. The first batch was produced using rainbow trout fillets and the second batch was produced using saithe fillets. For each batch, 2 kg of fillets was used. Sunflower oil and beef fat were purchased from a local supermarket and stored in a refrigerator for no more than 2 days before processing. Patent No. TR 2009 02207B (9) was used for the fish sausage production and the fish sausages were placed in a refrigerator (4.2 ± 1.2 °C) for 10 days before the tests.

Beef, chicken, and turkey sausages were purchased from refrigerated shelves of marketplaces. Five packages of sausages were purchased for each type of sausage. Each package was stored on the refrigerated shelves for less than 10 days before analyses. According to the Turkish Food Codex, these types of sausage products shall contain at least 67% meat. Meat proportions of the sausages were as follows: beef sausage was produced using 100% beef meat, chicken sausage was produced using 95% chicken and 5% beef, and turkey sausage was produced using 40% turkey, 40% chicken, and 20% beef.

Beef sausage ingredients: Beef meat and beef fat, potato starch, salt, spice mixture, soy protein concentrate, sodium polyphosphate, ascorbic acid, sodium nitrite, and water. The proportions were know-how formulated.

Chicken sausage ingredients: Chicken meat, beef meat and beef fat, potato starch, soy protein concentrate, spice mixture, salt, sodium polyphosphate, ascorbic acid, sodium nitrite, and water. The proportions were know-how formulated.

Turkey sausage ingredients: Turkey meat, chicken meat, beef meat and beef fat, sodium caseinate, potato starch, soy protein concentrate, spice mixture, salt, gluten, sodium polyphosphate, ascorbic acid, sodium nitrite, and water. The proportions were know-how formulated.

2.2. Fish sausage formulation

The formula and ingredients for both trout and saithe sausages were as follows: fish meat 67.84%; ice 16.30%; beef fat 5.1%; sunflower oil 5.09%; soy protein concentrate (SN 650, Heilongjiang Shuanghe Songnen Soybean Bioengineering Co., Ltd., Heilongjiang, China), 1.70%; modified potato starch (PenCling 530, Penford Food Ingredients Co., Centennial, CO, USA); 1.70%; salt 1.36%; sodium tripolyphosphate 0.17%; red pepper 0.07%; black pepper 0.14%; sugar 0.15%; pimento 0.04%; coriander 0.10%; ginger 0.10%; ascorbic acid 0.02%; sodium nitrite 0.02%; coloring 0.02% (just for saithe sausage), and monosodium glutamate 0.14%. The fish sausages were packed using vacuum packaging and a double pasteurization technique.

2.3. Texture profile analysis

Texture profile analysis (TPA) was performed using a TA-XT Plus texture analyzer (Stable Micro Systems, Godalming, UK) based on the method of Schubring (10). Prior to the analysis, sausage samples were equilibrated to ambient temperature for 30 min and cut into sections of 2 cm thick, cored into a cylinder with a diameter of 2.5 cm (P/25). From the resulting force/deformation curves, mechanical properties including hardness, cohesiveness, springiness, resilience, adhesiveness, and chewiness were evaluated.

2.4. Shear tests

Specimen loading, test conditions, and specimen preparation procedures were as described (11). The samples were compressed once at a crosshead speed of 0.80 mm/s to 60% of their original height using a Warner-Bratzler blade set (HDP/WBR with rectangular slot blade) with a 25-kg load cell. Maximum force to cut the sample, i.e. the shear force, and the work needed to move a Warner-Bratzler blade through the sample, i.e. the work of shearing, were recorded using the same texture analyzer as mentioned above. The firmness of each sample was also measured using the texture analyzer equipped with a Kramer shear-compression test cell (HDP/KS5, 5 blades). The cross-head speed used was 40.000 mm and the compression was set to 90 mm/min. Five replicates were placed in a cell individually and cut into certain pieces. Peak values were recorded as each sample was rupturing (12).

2.5. Pate penetration

Each minced sample was placed on a platform that had eight holes (HDP/MPT). The samples were compressed once at a crosshead distance of 15,000 mm/s using a probe containing eight needles. Puncture strength, penetration force, and penetration distance were set and measured to complete penetration of the probes through each sample. Test speed was 1.10 mm/s. Peak values were recorded during the drilling of each sample (13).

2.6. Expressible moisture and cooking loss

The expressible moisture was estimated as the quantity of liquid squeezed from each sliced sample (21 mm in diameter, 20 mm in thickness) upon compression. Measurement of expressible moisture was performed using a flat-ended cylinder probe 50 mm in diameter (P/50) at 90% deformation, held for 10 s in the TA-XT Plus texture analyzer (Stable Micro Systems) with minor modifications (14,15). The samples were compressed between layers of weighed Whatman filter papers no. 4 (7 × 7 cm). The speed of the probe was 0.8 mm/s. After compression, the filter paper was removed and the compressed samples were reweighed. The expressible moisture was calculated as: 100 × (initial weight – final weight) / initial weight. Cooking loss was measured by calculating the weight difference of each raw and cooked samples and was expressed as a percentage of the initial weight (16). Each sample was placed in a locked polyethylene bag and cooked in a 95 °C water bath for 10 min. Weight loss was measured as % cooking loss: 100 × (weight loss / initial weight).

2.7. Statistical analysis

Statistical analysis was carried out with SPSS 16.0. (SPSS Inc., Chicago, IL, USA) using Duncan's multiple range test to compare the differences among means. The values are presented as means ± standard deviations with the significance level set at $P < 0.05$.

3. Results

Analysis of variance showed that hardness, chewiness, and cohesiveness values were not significantly different ($P > 0.05$) between trout and saithe sausages. While the hardness value of saithe sausage was statistically close to that of chicken sausage, the hardness value of trout sausage was significantly different ($P < 0.05$) and weaker compared to the other sausages. Average values of TPA evaluation for each group are shown in Table 1. Each value corresponds to the mean value of ten replicates. Significant differences ($P < 0.05$) in adhesiveness, springiness, and resilience values of fish sausages were determined (Table 1). The hardness value was found significantly different ($P < 0.05$) for turkey and beef sausages. The hardness value of chicken sausage was not significantly different than the corresponding values of beef and saithe sausages. However, the other values of textural indicators were all significantly different, except the value of springiness for saithe, turkey, and beef sausages. From highest to lowest, the hardness values were ranked as turkey, beef, chicken, saithe, and trout.

The firmness values for all groups are shown in Table 2. The statistical analysis showed that there was no significant difference ($P > 0.05$) for the firmness values between sausage groups in the shear test. However, the firmness value of beef sausage was significantly different ($P < 0.05$) and higher compared to the firmness value of fish, chicken, and turkey sausages in the Kramer test. The firmness values of prepared trout and saithe sausages were found acceptable for the consumer. However, pate penetration values of the fish groups were significantly different from and weaker than the other measurements. The market sausages contained sodium caseinate in their formulation while the trout and saithe sausages did not.

One of the most important attributes in sausages and other emulsified products is the ability to hold moisture and fat inside the product. Cooking loss is a practical method for determining water and fat loss during cooking of sausages. The mean values of cooking loss for all groups are reported in Table 2. Analysis of variance showed that the values of cooking loss for chicken sausage were significantly different ($P > 0.05$) compared to the others. There was no significant difference between trout and saithe groups or between turkey and beef sausages as shown in Table 2.

Expressible moisture of muscles is another indicator for textural quality changes in sausage. Statistical comparisons, except for the statistical values of rainbow trout, revealed significantly higher and different values ($P < 0.05$). This suggests that the water holding capacity of trout sausage is weaker than those of the other groups. No significant difference ($P < 0.05$) was found in the saithe, chicken, turkey, and beef groups (Table 2).

Table 1. Comparison of texture profile indicators for the sausage groups.

Sausage samples	Hardness (N)	Adhesiveness (N s)	Springiness	Cohesiveness	Chewiness (N mm)	Resilience
Trout	46.45 ± 1.46^{a}	−17.24 ± 2.95^{a}	0.50 ± 0.05^{a}	0.37 ± 0.03^{a}	18.74 ± 2.21^{a}	0.20 ± 0.03^{a}
Saithe	50.65 ± 1.51^{ab}	−25.22 ± 3.30^{b}	0.84 ± 0.03^{b}	0.33 ± 0.02^{a}	15.63 ± 1.51^{a}	0.10 ± 0.01^{b}
Chicken	55.06 ± 1.48^{bd}	−39.50 ± 4.95^{c}	0.93 ± 0.02^{c}	0.68 ± 0.01^{b}	33.77 ± 1.76^{b}	0.34 ± 0.00^{c}
Turkey	73.14 ± 3.31^{c}	−17.12 ± 5.39^{ab}	0.85 ± 0.04^{bc}	0.28 ± 0.05^{a}	19.68 ± 3.59^{a}	0.13 ± 0.04^{b}
Beef	60.56 ± 2.31^{d}	−14.67 ± 3.07^{a}	0.89 ± 0.02^{bc}	0.35 ± 0.05^{a}	19.47 ± 2.37^{a}	0.14 ± 0.03^{b}

Data are expressed as mean ± standard deviation (n = 10).
Different superscript letters in the same column indicate significant differences ($P < 0.05$).

Table 2. Cooking loss and expressible moisture values and firmness comparison for the sausage groups using three texture tests.

Sausage samples	Kramer test		Shear test		Pate penetration		
	Firmness (N)	Work of shear (N s)	Firmness (N)	Work of shear (N s)	Firmness (N)	Cooking loss (%)	Expressible moisture (%)
Trout	65.27 ± 4.18 [a]	655.23 ± 42.20 [a]	6.48 ± 1.12 [a]	85.65 ± 2.31 [a]	1.79 ± 0.04 [a]	3.84 ± 0.19 [a]	3.72 ± 0.28 [a]
Saithe	72.33 ± 3.62 [a]	782.23 ± 25.35 [b]	4.53 ± 2.12 [a]	48.45 ± 2.65 [b]	2.25 ± 0.05 [b]	4.05 ± 0.24 [a]	2.65 ± 0.15 [b]
Chicken	74.30 ± 6.41 [a]	824.76 ± 65.50 [b]	6.15 ± 3.22 [a]	57.54 ± 3.22 [c]	2.73 ± 0.0 [c]	4.98 ± 0.36 [b]	2.59 ± 0.11 [b]
Turkey	62.95 ± 4.95 [a]	683.78 ± 31.29 [a]	10.42 ± 4.25 [a]	104.10 ± 4.25 [d]	2.76 ± 0.06 [c]	6.78 ± 0.05 [c]	2.80 ± 0.31 [b]
Beef	94.91 ± 4.92 [b]	976.21 ± 47.46 [c]	6.95 ± 1.91 [a]	72.42 ± 1.91 [e]	3.18 ± 0.09 [d]	6.61 ± 0.22 [c]	2.58 ± 0.31 [b]

Data are expressed as mean ± standard deviation (n = 10 for firmness and expressible moisture, n = 5 for cooking loss).
Different superscript letters in the same column indicate significant differences ($P < 0.05$).

4. Discussion

The low TPA results were related to the low fat content of each fish sausage. The ground animal sausages were produced using beef fat due to the Turkish Standards Institution (Turkish abbreviation: TSE) No. 980 Sausage Production Standard. The beef fat percentage should not be more than 10% of the final product. In fish sausage production, this fat percentage was met with 5% beef fat and 5% sunflower oil. The starch and soy protein concentrate ratios could cause weak but acceptable values, and 5% soy protein or potato starch rate is allowed to be used under Turkish standards and regulations (Turkish Food Codex). In the present study, soy protein concentrate was 1.7% and modified potato starch content was 1.7%. According to Kasapis et al. (17), potato starch and soy protein might improve the textural integrity and make fish sausage firmer. Cardoso et al. (18) studied South African hake sausages and reported that the weakest and highest hardness values of the control group were 27.7 N and 35.3 N, respectively. In this study, the hardness values of both prepared sausages were found to be higher as compared to previous studies (4,19). According to Dingstad et al. (19), a hardness value of 47.3 N or higher in a sausage generates at least 60% consumer willingness for purchase. Therefore, the textural profile of the prepared sausages was acceptable. The firmness and shear force are important among other texture properties for the consumer preference because these indicators determine the texture acceptability of a product (20). A lower cut-off point for the texture of comminuted food products including meat balls, frankfurters, and sausages would cause rejection by consumers (4,21,22). Therefore, this study was designed to understand the firmness properties by using three tests. The Shear test (Warner-Bratzler) was selected to simulate effectively the consumers' senses while cutting the product using a knife. The Kramer shear test was selected to identify the textural response of the sausage with a combination of compression, shearing, and extrusion with a five-bladed shear cell. Pate penetration test was used to evaluate puncture, strength, and penetration force of the minced sausages. Textural properties were investigated using different fat levels and sodium caseinate was found as the most effective nonmeat protein for improvement of texture (23). The different and weaker values provided by pate penetration test might be due to the lack of milk protein concentrate. Both fish sausages were found acceptable based on cutting test results. Another measurement for textural quality change in sausage is expressible moisture of muscles (24). According to Dunajski (25), fluctuations in water content may have a substantial impact on the texture of fish muscle. Lee and Toledo (26) evaluated free and mobilized water as textural indicators that provided the measurement of water holding capacity and juiciness effect on sensory perception of the sausage. In conclusion, the expressible moisture in different types of sausage is related to meat type and textural properties, even though the expressible moisture content demonstrated a low variation among each sample. The packaging and style are indispensable features for consumers, since color and appearance can trigger the consumers' willingness for purchasing the product.

The acceptability and textural differences of the two distinctive fish sausages were compared with the commercial beef, turkey, and chicken sausages that can be purchased in the Turkish food marketplaces. The comparison data reflected consumers' preferences for determining the potential market value of fish sausages. The evaluation and development of new and alternative fishery products carry utmost importance for Turkey seafood industry. This study suggests that the texture of prepared emulsion fish sausages using rainbow trout and saithe fillets was marketable. For future studies, the textural comparison of emulsion-type fish sausages is required to investigate cooking effects on the texture of fish sausages.

References

1. Wang P, Xu X, Zhou G. Effect of meat and phosphate level on water-holding capacity and texture of emulsion-type sausage during storage. Agricult Sci China 2009; 8: 1475–1481.
2. Dai RT, Wu GQ. Analysis of existing problems and the principle of processing emulsion-type sausage. Sci Technol Food Industry 2000; 21: 21–23.
3. Andres SC, Garcia ME, Zaritzky NE, Califano AN. Storage stability of low-fat chicken sausages. J Food Eng 2006; 72: 311–319.
4. Dincer T, Cakli S. Textural and sensory properties of fish sausage from rainbow trout. J Aqua Food Prod Technol 2010; 19: 238–248.
5. Dincer T, Cakli S, Kilinc B. Fish sausage production by using saithe (*Pollachius virens*) fillets and controlling the microbiological and chemical quality in cool storage. In: Proceedings of the 14th National Fisheries Symposium, Muğla, Turkey; 2007. p. 190.
6. Sikorski Z, Pan BS. Preservation of seafood quality. In: Shahidi F, Botta JR, editors. Seafoods: Chemistry, Processing Technology and Quality. Glasgow, UK: Blackie Academic & Professional; 1994. pp. 168–195.
7. Sawyer CA, Biglari SD, Thompson SS. Internal end temperature and survival of bacteria on meats with and without a polyvinyl chloride wrap during microwave cooking. J Food Sci 1984; 49: 972–974.
8. Botta JR. Instrument for non-destructive texture measurement of raw Atlantic cod fillets. J Food Sci 1991; 56: 962–964.
9. Dinçer T, Çaklı Ş. Fish Sausage Production. Patent No. TR 2009 02207B, 2012. Republic of Turkey National Patent.
10. Schubring R. Texture measurement on gutted cod during storage in ice using a hand-held instrument. Inf Fischwirtsch Fischereiforsch 2002; 49: 25–27.
11. Su YK, Bowers JA, Zayas JF. Physical characteristics and microstructure of reduced-fat frankfurters as affected by salt and emulsified fats stabilized with nonmeat proteins. J Food Sci 2000; 65: 123–128.
12. Kao WT, Lin KW. Quality of reduced-fat frankfurter modified by konjac–starch mixed gels. J Food Sci 2006; 71: 326–332.
13. Smewing J. Texture analysis. Meat Inter 1996; 6: 37–38.
14. Lee CM, Chung KH. Analysis of surimi gel properties by compression and penetration tests. J Texture Stud 1989; 20: 363–377.
15. LeBlanc RJ, LeBlanc EL. The effect of super chilling with CO_2 snow on the quality of commercially processed cod (*Gadus morhua*) and winter flounder (*Pseudopleuronectes americanus*) fillets. In: Huss HH, Jacobsen M, Liston J, editors. Quality Assurance in the Fish Industry. Amsterdam, the Netherlands: Elsevier Science Publishers; 1995. pp. 115–124.
16. Boles JA, Swan JE. Effect of post-slaughter processing and freezing on the functionality of hot-boned meat from young bull. Meat Sci 1996; 44: 11–18.
17. Kasapis S, Al-Oufi HS, Al-Maamari S. Minced Fish Products of Improved Eating Quality. Irish Patent, S2003 / 0921, 2003.
18. Cardoso C, Mendes R, Pedro S, Nunes ML. Quality changes during storage of fish sausages containing dietary fiber. J Aqua Food Prod Technol 2008; 17: 73–95.
19. Dingstad GI, Kubberøda E, Næsa T, Egelandsdal B. Critical quality constraints of sensory attributes in frankfurter type sausages, to be applied in optimization models. LWT-Food Sci Technol 2005; 38: 665–676.
20. Chambers EN, Bowers JR. Consumer perception of sensory quality in muscle Foods. J Food Technol 1993; 47: 116–120.
21. Yu SY, Yeang SB. Effects of type of starch on the quality of fishballs. In: Liang OB, Buchanan A, Fardiaz D, editors. Development of Food Science and Technology in Southeast Asia. Bogor, Indonesia: IPB Press; 1993. pp. 325–332.
22. Nurul H, Noryati I, Alistair TLJ. Physicochemical properties of Malaysian commercial beef frankfurter. In: Proceedings of the 23rd Scientific Conference of the Nutrition Society of Malaysia. Kuala Lumpur, Malaysia: SCNSM; 2008. pp. 128–130.
23. Yoo SS, Kook SH, Park SY, Shim JH, Chin KB. Physicochemical characteristics, textural properties and volatile compounds in comminuted sausages as affected by various fat levels and fat replacers. Int J Food Sci Technol 2007; 42: 1114–1122.
24. Olsson GB, Ofstad R, Lødemel JB, Olsen RL. Changes in water-holding capacity of halibut muscle during cold storage. Lebensm-Wiss Technol 2003; 36: 771–778.
25. Dunajski E. Texture of fish muscle. J Texture Stud 1979; 10: 301–318.
26. Lee CM, Toledo RT. Factors affecting textural characteristics of cooked comminuted fish muscle. J Food Sci 1976; 41: 391–397.