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Nutritional and sensory characteristics of locally produced canned tuna from Hadhramout, Yemen

Osan Maroof Bahurmiz [1*], Mohammed Al-Sa'ady [2], Frederick Adzitey [3]
[1, 2,] Department of Food Science and Technology, Hadhramout University, Mukalla, Yemen
[3] Department of Animal Science, University for Development Studies, Tamale, Ghana

Abstract
Fish canning is an important industry in the coastal region of Hadhramout province, south-east of Yemen. The area hosts all the three tuna canning factories of the country. The leading product (brand) of canned tuna in oil, Yellowfin tuna (*Thunnus albacares*), produced by each of these three factories, was evaluated for sensory (consumer preference) and nutritional (proximate composition) characteristics. Results of proximate composition showed no significant differences ($P > 0.05$) between the tested brands for the main nutritional components; moisture, protein and lipid, except for ash. Values (wet weight basis) were in the range of 59.77 - 63.11%, 23.33 - 24.56%, 8.05 - 8.97% and 2.01 - 2.25% for moisture, protein, lipid and ash, respectively. Sensory evaluation showed significant differences ($P< 0.05$) among the three brands for overall rating and most individual attributes. Nevertheless, all scores were within the "like" zone of the preference scale, irrespective of the brand.

Keywords: proximate composition, sensory evaluation, canned tuna, Yemen

1. Introduction
Fish is an important component of the diet of humans providing nutrients needed by the human body to function properly [1]. It is also a rich source of proteins of high biological value, with balanced amino acids and high digestibility of greater than 90%. Fish lipids are of high quality containing low saturated fat and high content of essential fatty acids, particularly omega-3 long-chain polyunsaturated fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) [2]. Fish is also a major source for many vitamins and minerals known to support good health [1-3]. The consumption of fish and/or fish oil is well-documented to be associated with many health benefits like prevention of coronary heart disease and thrombosis, improved pregnancy outcomes, fewer preterm and low birth weight deliveries [4, 5]. Nevertheless, fish is well-known as a highly perishable food with very limited shelf-life [6]. Low-temperature preservation, particularly freezing and subsequent cold storage is a main preservation method that has been widely and successfully used to further prolong the shelf-life of fish in a manner that the product retains most of its characteristic properties. The shelf-life of good-handled frozen fish can be extended for up 1 to 2 years, particularly for lean "low-fat" fish [7]. However in the light of the modern consumer's lifestyle, frozen fish is still considered as raw fish that need further processing and/or cooking to be ready for consumption. Canning is one of the most effective and spreading method of fish preservation [8]. The pre-cooking and further thermal treatment of fish in hermetically sealed containers eliminate bacterial and autolytic spoilage, and pathogenic microorganisms, particularly the heat resistant *Clostridium botulinum* that can produce a lethal toxin with extended shelf-life beyond 2 years at ambient temperature [9, 10]. This along with other operations through the canning process will prepare the resulting product to be ready for consumption, which is convenient with the modern consumer's lifestyle. Nevertheless, prolonged heating at high temperatures will result in certain disadvantages in product quality such as alter its sensory attributes and loss of some vitamins, essential amino acids and unsaturated fatty acids as well as formation of some harmful compounds [9]. Thus, the canning process should be designed in such a way that avoid unwanted changes in sensory qualities and ensure that nutritional constituents present in the initial matter are retained to the maximum to serve human nutrition [11, 12].

Many fish species can be canned, but not all. In certain species the flesh disintegrates after the heat treatment making them unsuitable for canning [12]. Tunas (skipjack, yellowfin and albacore), bonitos, sardines, herrings, shrimps, prawns and salmon are the species commonly utilized in fish canning. Among the tunas, yellowfin tuna (*Thunnus albacares*) is one of the preferred species for canning [13, 14]. Freshwater and farmed species such as carp, chub and rohu have been also introduced for canning [15].

In Yemen, the fish canning industry was established in the late 1970th with two governmental factories producing canned sardine (Indian oil sardine, *Sardinella longiceps*), mackerel (Indian mackerel, *Rastrelliger kanagurta*) and yellowfin tuna. Currently, there are three local fish canning factories. All of them produce mainly canned tuna of the yellowfin species, with very little production of Longtail tuna (*Thunnus tonggol*) [16]. However, after about 40 years of existence, we could not find any scientific information regarding the quality of the produced products, especially canned tuna. The current study was therefore, carried out to evaluate and compare the nutritional and sensory characteristics of the main brands of local canned tuna by providing data on the proximate composition and consumer preference of these products.

2. Materials and Methods

2.1 Sampling

The leading three brands of canned tuna, each corresponding to one of the three local tuna canning factories of the country were used in this study.

Samples, 185g standard cans, were randomly purchased from local markets in Mukalla city, Hadhramout, Yemen, in the period of August - October 2016. To insure consistency between different brands and within individuals from the same brand, the collection of samples was done according to the following criteria: 1) the absence of any exterior defects such as container integrity defects or can ends, 2) the product should be within 6 to 12 months of its production date, and 3) samples among the same brand should be of different production serial numbers. Open cans were further examined before subjected to analyses. The can's content was free from any foreign material and products that appeared to be affected by distinct discoloration, persistent and distinct objectionable odors or flavors indicative of decomposition or rancidity, or uncharacteristic texture were excluded [17].

2.2 Proximate composition

Proximate composition analysis was carried out for drained samples of canned tuna to determine moisture, crude protein, crude lipid and ash following the methodologies of Association of Official Analytical Chemists, AOAC [18]. In brief, moisture content was determined by drying samples in an oven at 105ºC until constant weight. Determination of crude protein was done by Kjeldahl method. Approximately 1 g of dried finely-ground sub-samples were digested by concentrated H_2SO_4 plus catalyst (selenium) at 420ºC for 60 min. Digested samples were allowed to cool down at room temperature before adding distilled water and then alkali (40% NaOH) distillation, followed by acid (0.1 N HCl) titration. Crude lipid was determined by Soxhlet extraction unit using diethyl ether. Determination of ash was done by dry ashing at 550 ºC in a muffle furnace for 5 – 6 h.

2.3 Consumer sensory evaluation

Sensory evaluation was conducted to assess consumers preference for canned tuna in terms of the following attributes; colour, filling medium transparency, filling form (the consistency of pieces and the proportion of free flakes), aroma, taste, texture (month feeling) and general acceptability. The test was carried out using a seven-point hedonic scale; where, 7 = like extremely; 6 = like moderately; 5 = like slightly; 4 = neither like nor dislike; 3 = dislike slightly; 2 = dislike very much; 1= dislike extremely [19]. The evaluation was conducted in the same day but into two successive evaluation sessions; in the 1st session, cans were just opened and the evaluation was conducted for the product's aroma, color, filling medium transparency and filling form of the whole content. While, in the 2nd session, the taste and texture was evaluated for the drained samples. The overall rating for tested samples was evaluated as general acceptability (the overall impression of the assessors towards whole and drained samples) and calculated overall means for all the seven individual attributes. Drained samples were prepared by draining off the cans for about 15 min, and drained samples were portioned and distributed over clear round plastic containers (50 mm diameter). For both sessions, each of the samples was labelled with a random three-digit number and served individually to the consumers. The evaluation sessions were carried out at laboratories of the Department Food Science and Technology, Faculty of Environmental Sciences and Marine Biology, Hadhramout University (Mukalla, Yemen), using 60 voluntary tuna consumers consisting of students and staff of Hadhramout University. A brief introduction about each of the sensory test was read to the assessors before the commencement and each assessor was allowed to work at his/her own speed during the evaluation sessions.

2.4 Statistical analysis

Analysis of variance (ANOVA) was used to analyse experimental data and the differences between means were determined by Duncan's Multiple Range Test [20]. The test were carried out using the SPSS program, version 17.0 for Windows (SPSS lnc., Chicago, IL, USA) and the statistical means were considered to be significant at a P value of < 0.05.

3. Results and Discussion

3.1 Proximate composition

Results of proximate composition showed no statistically differences ($P < 0.05$) among all the brands in all nutritional components except the ash content (Table 1). Tuna meat from all brands contained the following values; 61.30% to 63.52 ***%*** of moisture, 23.12% to 25.02% of protein, 11.18% to 12.26% of lipid and 1.27% to 1.88% of ash.

Table 1: Proximate composition (% wet weight) of tested canned yellowfin tuna[1]

Sample/Composition	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)
Brand no. 1.	63.52 ± 2.00	23.12± 1.10	11.28 ± 0.88	1.88 ± 0.26 [a]
Brand no. 2.	61.30 ± 1.45	25.02± 0.05	12.26 ± 0.36	1.36 ± 0.05 [b]
Brand no. 3.	63.20 ± 0.86	24.30± 0.02	11.18 ± 0.20	1.27 ± 0.18 [b]
Raw tuna[2]	74.00 ± 1.08	22.52 ± 0.15	2.46 ± 0.07	1.25 ± 0.01

[1] Values were reported as means ± S.D. Within the different brands, mean values in the same column with different superscripts were significantly different ($P < 0.05$).

[2] Our unpublished data.

These values are comparable with results of proximate composition (the main nutritional constituents) reported for canned product in oil from yellowfin tuna [14]. Yellowfin tuna is well-documented as a lean fish with high protein and low lipid contents [21, 22]. The proximate composition of the raw meat of local yellowfin tuna has been reported to be 74.00, 22.52, 2.46 and 1.25% for moisture, protein, lipid and ash, respectively (our unpublished data).

Canning process, including the addition of filling medium, has been found to affect the nutrient content of the final product compared with that of the raw ones [11, 23, 24, 25]. This effect was found in the current study in terms of moisture (decreased) and fat (increased) contents. The same trend has been reported in albacore tuna, *Thunnus alalunga* [26-28] and in yellowfin tuna [14]. However, the effect of canning on protein content is less obvious and with no stable trend; either towards increasing the protein content [27, 28] or decreasing it [14, 29, 30].

Many operations during the tuna canning process contribute to the reduction of moisture content in the final canned product. The thermal treatment (pre-cooking and heat sterilization) denaturize the muscle proteins and thus decrease their water holding capacity which results in releasing a considerable amount of water to the surrounding medium [11, 12]. Additional moisture may also be released from fish muscles as a result of evaporation during the cooling of pre-cooked meat and the pressing step just before filling the meat in cans [11, 14, 30]. The lipid content was particularly high in all samples which is principally attributed to the use of oil as the filling medium. Although all samples were allowed to drain off before being subjected to proximate composition, the process was not enough to thorough drain the added vegetable oil from the final product. Fish protein is of high quality because it has higher digestibility value and contains all essential amino acids that human body cannot synthesize [1]. The average protein content of the tested samples was 24.54%, which is satisfy the criteria specified for high-quality animal products [31].

The non-significant differences ($P< 0.05$) in the main macronutrients (moisture, protein and lipid) among the three brands of tuna tested in the current study is not strange as the raw fishery material used for all of these products is based on local landing of yellowfin tuna (*Thunnus albacares*). Besides, the manufacturing process applied for all of these products is almost the same except for the pre-cooking process. Steam-cooking is used to produce brand no. 2 and brand no. 3, while boiling in brine is used to produce brand no. 1. It is well known that longer contact of fish muscle with brine increases the ash content in the final product [12]. For canned fish particularly, using brine as filling medium led to increase in the ash content of canned catfish as a result of the absorption of salt from the brine [25]. Consequently, the significantly higher ($P< 0.05$) ash content in the product (brand no. 1) compared with the other two brands tested in the current study could be attributed to the use of brine as the pre-cooking medium.

3.2 Consumer sensory evaluation

Results of sensory evaluation are presented in Table 2 and Figure 1 and 2. Irrespective of the significant differences ($P< 0.05$) showed among the three brands of canned tuna, all values for overall means and individual attributes were greater than score 4. This means the panel of consumers judged the canned tuna from the three brands to be within the "like" zone of the preference scale.

The overall means for all the seven attributes ranged from 4.86 to 5.80 (Table 2). These values demonstrated that the preference of consumers was more pronounced towards the canned tuna of brand no. 3, followed by brand no. 1 and brand no. 2.

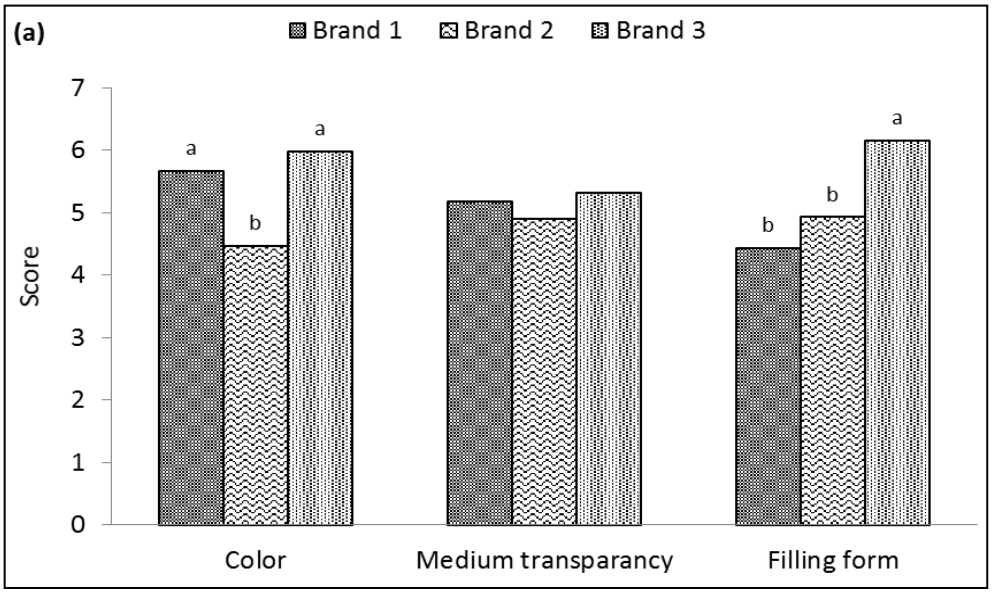
Table 2: Overall means for sensory evaluation of tested canned yellowfin tuna[1]

Sample/Rating	Score	Preference[2]
Brand no. 1	5.30 ± 0.49^{ab}	Like moderately
Brand no. 2	4.86 ± 4.86^{b}	Like slightly
Brand no. 3	5.80 ± 0.27^{a}	Like moderately

[1] Calculated overall means for all the seven individual attributes. Values were reported as means ± S.D. Within the different brands, mean values in the same column with different superscripts were significantly different ($P< 0.05$).

[2] Based on a seven-point hedonic scale; where, 7 = like extremely; 6 = like moderately; 5 = like slightly; 4 = neither like nor dislike; 3 = dislike slightly; 2 = dislike very much; 1= dislike extremely

As for individual attributes (Fig. 1; a and b), results were significantly differed ($P< 0.05$) among the three brands of canned tuna for all attributes, except the medium transparency.



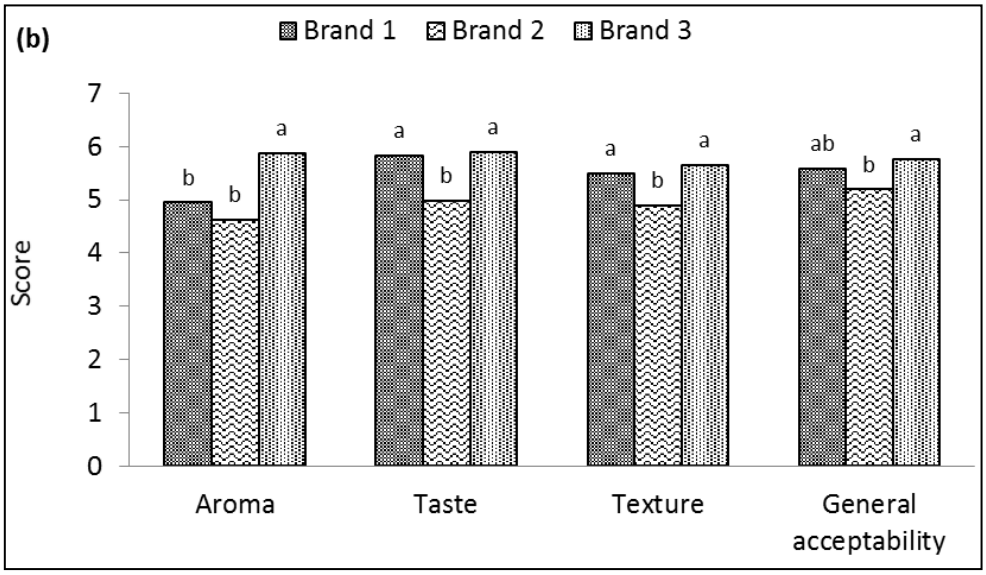


Fig 1: Sensory evaluation of tested canned yellowfin tuna from different brands[1]: **(a):** Scores for product's appearance; color, filling medium transparency and filling form. **(b):** Scores for product's aroma, taste, texture and general acceptability. [1] Values were reported as means ± S.D. Within the same attribute, mean values in the same column with different superscripts were significantly different ($P < 0.05$).

Brand no. 3 and brand no. 1 were scored highest ($P < 0.05$) for colour. Canned tuna of brand no. 3 was scored the highest ($P < 0.05$) for filling form. This was followed by brand no. 2 and brand no. 1 which did not differ significantly ($P < 0.05$) from each other. Although results of medium transparency did not differ significantly ($P < 0.05$) among the 3 canned tuna brands, the score was noticeably higher for brand no. 3 and brand no 1. The remaining attributes; aroma, taste, texture and general acceptability mostly followed the same trend as for the appearance attributes. The highest scores ($P < 0.05$) for taste and texture were equally assigned to tuna of brand no. 3, alongside with that of brand no. 1. Aroma scores were markedly higher ($P < 0.05$) for tuna of brand no. 3 compared with the other two brands. The general trend of rating for individual attributes also confirmed that the panel of consumer mostly preferred the product of brand no. 3, followed by brand no. 1, while brand no. 2 was rated least.

Another indicator that can be extracted from the results of sensory evaluation is the percentage of general acceptability (Fig. 2). These results showed that the general acceptability of these products was liked by 76.3 to 88.1% of the consumers, and was disliked by 3.39 to 15.3% of them. General acceptability of brand no. 3 achieved the highest and the lowest percentage of consumers who liked and disliked this product, respectively.

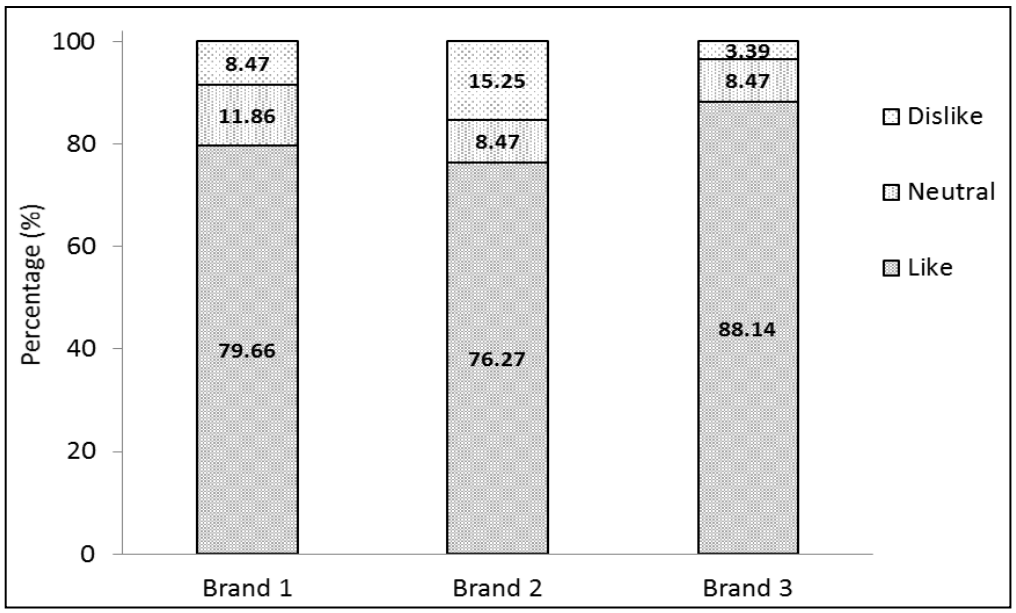


Fig 2: The percentage (%) of the product's general acceptability tested canned yellowfin tuna [1] [1]Values were reported as means ± S.D. Within the same attribute, mean values in the same column with different superscripts were significantly different ($P < 0.05$).

Product appearance is one of the most important quality parameter and usually it's the first impression by which consumers take in making a decision to purchase a product [32]. Canned tuna has a characteristic white color. The whitening of the flesh of canned tuna has been attributed to leaching of muscle pigments during pre-cooking, followed by thermal processing and leaching of white connective tissue containing collagen during the heating process [14, 33]. However, loss of this distinguishing color could occur due to various aspects of quality deterioration during handling and storage of raw fish, or during processing and further storage. Common types of discoloration of canned fish are pigment degradation, browning reactions such as the Maillard reaction and oxidation of ascorbic acid. Considerable loss in colour of canned fish may cause by technical issues during processing such excessive heating and longer processing time [33].

Processing-related factors like the type of retort and packaging material [33], the filling ingredients [13] as well as the filling medium [11, 14] have been documented to affect the quality of canned fish. The latter authors [14] found that the use of different vegetable oils as the filling medium for canned yellowfin tuna significantly affected the textural and color properties of the final product.

The quality of raw material utilized in the processing of the canned product, which continuously changes during storage prior to processing is another main issue affecting the final product quality [11]. In the current study, locally landed yellowfin tuna is the main raw material used in the manufacturing of the three brands of canned tuna. However, we cannot confirm the quality of fish at the reception point of each cannery. Based on our observation, there is a large variation in the quality of raw fishery material (fresh landed tuna and frozen stock) that were utilized in the local fish canning industries. All catch of yellowfin tuna in Yemen is currently from artisanal fisheries. Nevertheless, the quality of fish landed varied widely, primarily according to the fishing conditions and the consequently post-catch handling and storage practices. Generally, batches from the local coastal-catch where the fishing trip is very short, usually less than 12 hours, are of good quality, whereas those form long offshore fishing trips, with a trip up to one month, are of less quality. Rough handling, insufficient ice or freezing as well as bad stowage and storage conditions, particularly during the high production seasons are the main factors that deteriorate the quality of raw fish in Yemen. Hygienic and handling conditions during the manufacturing process also need to be improved.

Yemini canned tuna is well-known in the local and regional market for its premium quality, which has been accumulated over more than 30 years. Therefore, to maintain good standards particularly in the light of increasing competition from imported brands more concern should be paid to raw fishery materials by ensuring good handling and manufacturing practices.

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