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Research Article

Effect of turmeric on the quality of canned African catfish in tomato sauce during storage at 25°C and 45°C

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Abstract
The aim of the study was to investigate the preservative effect of turmeric paste on African catfish in tomato sauce with a view to producing ready-to-eat catfish and reduce the stress of processing. The microorganisms associated with the products were enumerated, isolated and identified, lipid oxidation was monitored, and the organoleptic properties were assessed. The microbial load ranged between 0.000 and 2.635 log cfu/g during storage. *Bacillus subtilis* and *Bacillus coagulans* were isolated and there was no presence of pathogenic microorganisms. The range of free fatty acid, peroxide and thiobarbituric acid values were 0.3 – 0.5% oleic acid, 0.00 – 0.07 meqO_2/kg of sample and 0.00 – 4.69 mg MDA/g respectively. Addition of turmeric had no significant effect ($p > 0.05$) on the taste, texture, aroma, colour and overall acceptability of the canned African catfish in tomato sauce samples. This study therefore established that addition of 3% and 4% turmeric paste to African catfish was effective in limiting microbial growth and reducing hydrolytic rancidity without having negative effect on consumer acceptability.

Keywords: turmeric, canned, African catfish, tomato sauce, free fatty acid, peroxide value, overall acceptability

Abbreviations: FFA – free fatty acids, TBA value – 2-thiobarbituric acid reactive substances, POV – peroxide value

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Introduction

Fish is an important source of animal protein due to its high nutritional value, good quality protein containing essential amino acids, digestibility, unsaturated fatty acid and important minerals. However, the rate of oxidation of fish lipid is high because of high level of unsaturation (Dragoev 1999; Hwang et al. 2004; Kumar 2017) and fish accounts for about 37% of Nigeria's total protein intake (Agbabiaka 2012).

Catfish is one of the most popular fresh water fish in the world. African catfish (*Clarias gariepinus*) is one of the most important species for commercial fish farming in Africa due to its high growth rate of about one kilogram at age six month. African catfish can adapt to and thrive even when the quality of water is poor (Hecht et al. 1996; Idahor et al. 2018). The demand for catfish is high in Nigeria because it is important in the production of diverse Nigerian cuisine (Idahor et al. 2018). World Health Organization recommended, 1 to 2 serving of fish weekly to provide about 200 – 500 mg n-3 PUFA (Tediosi et al. 2015; Wallin et al. 2015; Mei et al. 2019). Despite their nutritional benefit, catfish deteriorates very fast after harvesting from the fresh water or pond if not preserved immediately hence, the need for canning.

Canned foods are aseptically packed in hermetically sealed containers, commercially sterile and shelf stable for a specific period of time (Kyosev and Dragoev 2009). Canning served to destroy both spoilage and pathogenic microorganisms in food (Oranusi et al. 2012). To prevent the growth of these pathogenic microorganism in canned food, there is a need for an inclusion of preservative either as sauce or chemical additives. Tomato is an important fruit that plays an important role in the daily diet. It is the major ingredient for the production of fish sauce. It is rich in health promoting substances such as lycopene, β-carotene, α-tocopherol, vitamin C, total phenolic and flavonoid contents (Lana et al. 2006; Lenucci et al. 2006; Slimestad and Verheul 2009; Gokoglu et al. 2012).

Fish lipids are made up of 40% unsaturated long chain fatty acids which are highly susceptible to degradation. This leads to release of volatile compound that gives off-flavour and cause deterioration in the sensory quality of food (Maqsood et al. 2012; Secci and Parisi 2016). Synergistic effects of lycopene-β-carotene and lycopene- α-tocopherol combinations were reported as inhibition of oxidation (Zanfini et al. 2010; Gokoglu et al. 2012).

The increase in the awareness for safe foods, with no or less chemical additives has increased the study of bio preservatives, as a replacement to chemical preservatives (Rasooli 2007; Malomo et al. 2020). Turmeric (*Curcuma longa*), in *Zingiberaceae* family is one of the most popular spices in food processing both on domestic and commercial basis. It contains natural antioxidants, and has been reported to possess numerous medicinal properties, antioxidant and antimicrobial activities (Tuba and Ilhamin 2008; Lim et al. 2010). The major bioactive constituents of turmeric are Curcuminoids (mostly curcumin) and essential oils (primarily monoterpenes). It also contains phenolic substances such as Calebin-A, vanillic acid, vanilli, quercetin (Tanvir et al. 2017). Fresh catfish unlike other species of fish is difficult to prepare because of the presence of slime on the fish flesh. Many studies have been carried out on fish (Hwang et al., 2004; Idahor et al. 2018; ElShehawy and Farag 2019). These studies employed processing operations such as smoking (Oladosu-Ajayi et al. 2020), use of hurdle technology (use of bio preservatives, packaging materials and varying storage temperatures) in extending the shelf life of catfish. Nevertheless, there is no information on canning of African catfish, hence this study. The aim of this study is to determine the effect of turmeric on the microbiological, physicochemical and sensory properties of canned African catfish in tomato sauce during storage at 25ºC and 45ºC.

Materials and Methods

Materials. African catfish and cherry tomatoes were obtained from Obafemi Awolowo University Teaching and Research farm while turmeric was obtained from Oja tuntun in Ile-Ife. African catfish was transported to the laboratory in a cooler containing ice cube. Microbiological media and chemicals used were of analytical grade.

Preparation of turmeric paste. The turmeric rhizome was prepared by washing to remove all impurities, peeling and wet milling using a blender, to obtain turmeric paste (Modified method of Olaniran et al. 2015).

Preparation of tomato sauce. A modified method of Olaniran et al. (2015) was used in the production of tomato sauce. Wholesome tomato fruits were selected from the lot and washed in portable water to remove sand and any form of impurities. The fruits were crushed, heated, and screened to obtain pulp and the resulting pulp was concentrated to tomato sauce of 12% total solids by boiling in a stainless-steel pot. After concentration, the sauce was divided into three portions, labeled A to C. Sample A served as the control, 3% and 4% turmeric paste were added to samples B and C respectively and each sample was kept at 25ºC and 45ºC. Commercial canned mackerel served as comparative control.

Preparation of African catfish. African catfish was caught in July with an average weight of 700 g. Fresh African Catfish (*Clarias gariepinus*) were slaughtered and transported to the laboratory on ice. Fish was gutted and washed using portable water. Catfish were soaked in hot brine solution for 10 min to facilitate removal of slime and cut into chunks of 2.5 cm.

Preparation of canned catfish in tomato sauce. The soaked catfish was precooked for 15 min, the bouillon was drained and each chunk was placed in the can. Tomato paste was added to give a headspace of 5 mm, the net weight was adjusted to 160 g and the cans were closed by exhausting and seaming, placed in retort at 121° for 30 min and cooled under running water. The samples were divided into two portions. A group was stored at 25°C while the other group was stored at 45°C (Modified method of Naik et al. 2014). The storage temperatures were selected based on sub-Saharan African weather.

Microbiological Analysis. The microbial load of the samples were analyzed on a weekly basis using the pour plate method. Each sample (5 ml) was weighed into stomacher bag and homogenized with 45 ml of peptone water using a stomacher (Colworth 400 Model 6021, United States). The homogenized sample was serially diluted and 1.0 ml of the representative dilution was dispensed into Petri dish. Molten sterile nutrient agar (20 ml) was poured into the Petri dish and rocked clockwise and anticlockwise to ensure even distribution of growth. Plates were incubated at 37°C for 24 h. and Colonies on each plate were counted using a Gallenkamp colony counter. Pure isolates were obtained by streaking the colonies on solidified nutrient agar, incubated at 37°C and then restreaked on agar slant in a McCartney bottle at refrigeration temperature (4 ± 2°C) (Harrigan 1998; Malomo et al. 2020). Bacterial isolates were identified using cultural and morphological characteristics, Gram's staining techniques and biochemical tests following the scheme of Harrigan (1998) and Paul de Vos et al. (2010) were used to identify the isolates.

Physico-chemical analysis. Peroxide value was determined using the spectrophotometric method described by Shantha and Decker (1994) in Hornero-Mendez et al. (2001), free fatty acid (FFA) was determined using titrimetric method by Pearson (1976) and El-Abassy et al. (2009) and Thiobarbituric acid was by the spectrophotometric method described by Papastergiadis et al. (2012).

Sensory analysis. Sensory evaluation was conducted using the method of Larmond (1977).

Statistical Analysis. Data obtained from the experiment were subjected to analysis using SPSS for Least significant difference, and XLSTAT (2014) for principal component analysis.

Results and Discussion

Total plate count of canned African catfish in tomato sauce. The total viable count of canned catfish in tomato sauce samples was between the range of 0.000 – 0.885 log cfu/g during the period of storage (Table 1). The initial total plate count decreased significantly ($p < 0.05$) with the addition of turmeric. Count in the control samples (without turmeric) stored at 25 and 45°C (Samples A25 and A45) were less than 1.0 log cfu/g at the beginning of storage and no plate count was recorded in the samples with 3 and 4% turmeric paste stored at 25 and 45°C (Samples B25, B45, C25 and C45). The absence of viable microorganism could be due to the destruction or/and injury of microbial cell through the synergistic effect of sterilization and addition of turmeric. Lim et al. (2010) reported that turmeric has antimicrobial and antioxidant properties. Total plate counts were significantly lower ($p < 0.05$) in samples stored at 45°C at week one (0.830 - 1.465 log cfu/g) than samples stored at 25°C (1.154 - 2.040 log cfu/g). It increased significantly ($p < 0.05$) in all samples from week 1 to week 2 but there was no significant difference ($p > 0.05$) in the total plate counts from week two to week three though, slight

decrease was observed in B25 and C25. Sample C25 had the lowest total plate count from week two to week three (1.166 - 1.156 log cfu/g). Total plate count was generally higher in samples stored at 45°C (2.069 - 2.635 log cfu/g) than 25°C (1.126 - 2.154 log cfu/g) at week 2 to week 3 but there was no significant difference ($p > 0.05$) in the total plate count of all the samples from week two to week three showing that lack of oxygen and addition of turmeric had negative effect on the microorganisms. Higher total plate count observed in samples stored at 45°C could be due to the effect of temperature on germination of spores. This is in agreement with Oranusi et al. (2012) that reported higher count of both aerobic and anaerobic bacteria at the temperature range of 37 - 55°C in ready-to-eat foods. All counts were not more than 10^2 cfu/g which was below the International Commission on Microbiological Specifications for Foods (ICMSF) maximum limit of 1.0 x 10^6 cfu/g (ElShehawy and Farag 2019).

Microorganisms isolated from canned catfish in tomato sauce. *Bacillus subtilis* and *Bacillus coagulans* were isolated from the products during storage. *Bacillus subtilis* was only isolated from samples B25, B45, C25 and C45 at the first week of storage while *Bacillus coagulans* was present throughout the period of storage but there was no significant increase ($p<0.05$) in the *Bacillus* count from week two to three though a decrease was observed in samples B25, C25 and C45.The presence of these microorganisms from week 1 to week 2 could be due to germination of heat resistant spores and the reduction in population could be due to effectiveness of turmeric and depletion of oxygen.

Table 1. Total plate count (TPC) of African catfish in tomato sauce with or without turmeric paste (log cfu/g)

	Storage time (weeks)			
Sample	**0**	**1**	**2**	**3**
A45	0.895^{b}±0.02	1.465^{c}±0.06	2.617^{d}±0.05	2.635^{c}±0.04
A25	0.895^{b}±0.02	2.040^{d}±0.01	2.101^{c}±0.03	2.154^{b}±0.01
B45	0.000^{a}±0.00	0.965^{ab}±0.05	2.149^{c}±0.03	2.195^{b}±0.01
B25	0.000^{a}±0.00	1.360^{c}±0.10	1.813^{b}±0.06	1.211^{a}±0.23
C45	0.000^{a}±0.00	0.830^{a}±0.09	2.069^{c}±0.09	2.052^{b}±0.07
C25	0.000^{a}±0.00	1.154^{b}± 0.08	1.166^{a}±0.05	1.126^{a}±0.03

A: Canned African catfish in tomato sauce, B: Canned African catfish in tomato sauce with 3% turmeric paste, C: Canned African catfish in tomato sauce with 4% turmeric paste.Values are means of three replicates ± standard deviation. Means followed by different superscript in the same column are significantly different at $p < 0.05$

Bacillus coagulans is moderately thermophilic, facultatively anaerobic which grows optimally between, 40°C and 57°C, and has the maximum temperature of 61°C. It can be found in canned food, tomato juice, gelatin and milk (De Vos et al. 2009). Oranusi et al. (2012) also isolated *B. coagulans* from canned tomato.

All canned catfish in tomato sauce samples were physically examined and there was no change in colour, texture and aroma except in samples B45 and C45 with strong turmeric aroma at the end of the third week. Elshehawy and Farag (2019) also reported the growth of aerobic spore formers in canned mackerel. *Clostridium*, *Staphylococcus* and *coliform* and any other pathogenic organisms were not detected in the samples.

Lipid oxidation changes. Oxidation reaction in oily food leads to the production of hydro peroxides, which later leads to the formation of secondary products like aldehydes and ketones (Balev et al. 2011; Liu and Chen 2019).

Free fatty acid measures the extent of hydrolytic rancidity in a food sample. The free fatty acid (FFA)

content of the canned African fish in tomato sauce generally decreased during storage at 25°C and 45ºC (Fig. 1).

Canned African fish in tomato sauce sample without turmeric had higher FFA (0.44 – 0.50% oleic acid) compared with samples with turmeric and was also higher at 45°C than 25°C. This may be due to increase in rate of formation of free fatty acid which may stimulate oxidation (Dragoev et al. 2014). The addition of turmeric reduced the free radicals in the samples and the FFA decreased with increase in the concentration of turmeric paste. The aqueous and ethanol extracts of turmeric show significant antioxidant characteristics through the increase in antioxidant enzymes, scavenging different free radicals, and inhibiting lipid peroxidation (Karimi 2008).

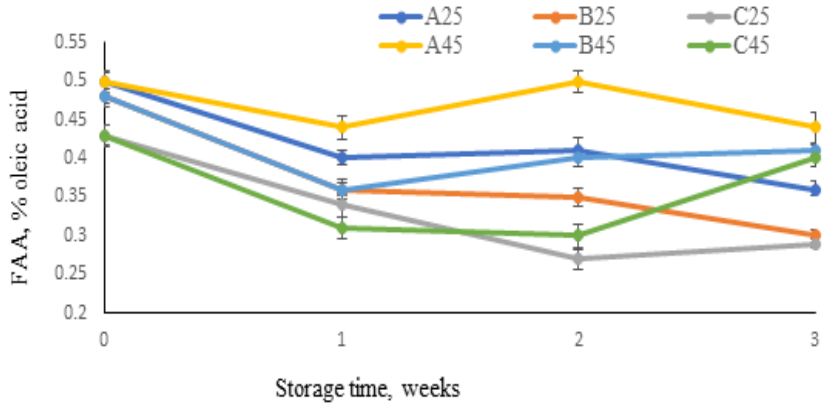

Figure 1. Free fatty acid composition of canned African catfish in tomato sauce with or without turmeric paste A: Canned African catfish in tomato sauce, B: Canned African catfish in tomato sauce with 3% turmeric paste, C: Canned African catfish in tomato sauce with 4% turmeric paste

The Peroxide value (POV) of canned African catfish in tomato sauce with or without turmeric showed the level of oxidation or rancidity at early oxidation stage by quantifying the hydro peroxide (Figure. 2). It was within the range of 0.00 and 0.07 meqO_2/kg and sample containing 3% turmeric paste (sample B25) had the lowest through the period of storage. Bio preservatives such as antioxidant ability (Ogueke et al. 2018; He et al. 2020). It was observed that the addition of 3% turmeric paste was more effective in limiting production of peroxide than 4% turmeric paste in the samples. High production of peroxide in samples C25 and C45 could be because the preservative acted as a prooxidant, thereby causing rancidity of the fish lipid. Certain antioxidants such as ascorbic acid and phenolic substances have been reported to behave as prooxidants at higher levels (Seo and Lee 2002; Asplund et al. 2002; Gonzalez et al. 2005). The thiobarbituric acid value (TBA value) is used to quantify secondary oxidation products by measuring the amount of malondialdehyde. The thiobarbituric acid value of canned African catfish in tomato sauce with or without turmeric ranged between 0.00 and 4.69 mg MDA/g of sample during the period of storage at 25 and 45°C (Fig. 3). TBA value was not detected in samples B25 and B45 throughout the period of storage. This is an indication of the effectiveness of 3% turmeric paste as an antioxidant in limiting lipid oxidation in the samples during storage at both 25 and 45°C.

It was also lower in samples A25 and A45 than C25 and C24 from week1 to week 3. The reason for the high value of TBA observed in samples C25 and C45 indicated that at a concentration of 4%, turmeric paste acted as prooxidant. Thus, rate of lipid oxidation was enhanced and faster in samples C25 and C45 compared to samples A25 and A45. Also, storage of canned catfish samples at high temperature is one of the factors that encourages lipid oxidation in food products (Liu et al. 2019).

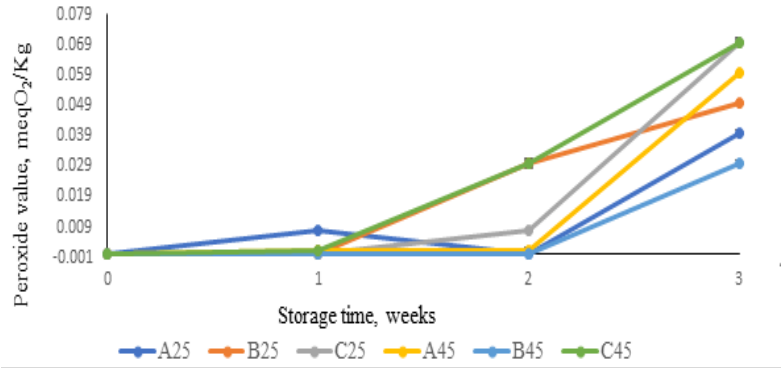

Figure 2. Peroxide value of African catfish in tomato sauce with or without turmeric paste. A: Canned African catfish in tomato sauce, B: Canned African catfish in tomato sauce with 3% turmeric paste, C: Canned African catfish in tomato sauce with 4% turmeric paste

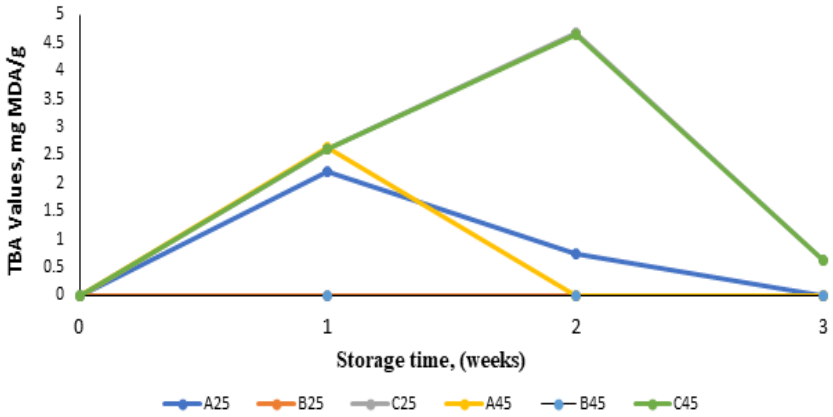

Figure 3. Thiobarbituric acid value of canned African catfish in tomato sauce with or without turmeric paste. A: Canned African catfish in tomato sauce, B: Canned African catfish in tomato sauce with 3% turmeric paste, C: Canned African catfish in tomato sauce with 4% turmeric paste

Interaction occurred between the antioxidative property of turmeric and storage time, and storage temperature. Famurewa et al. (2017) also reported higher level of TBA value in African catfish at high temperature. Peroxide value of the samples was below the permissible 10 meqO_2/kg of sample recommended by CODEX Alimentarius Commission (1997) and Ozyurt et al. (2013).

Principal component analysis of canned African catfish in tomato sauce. The biplot showed that the PC1 accounted for 56.97% while PC2 accounted for 19.97% (Figure 4). Samples C had the lowest FFA while sample A had the highest showing that the higher the concentration of turmeric, the lower the rate of production of FFA. B had the lowest level of TBA value and PV at both 45ºC and 25ºC but addition of 3% turmeric paste was more effective in sample B stored at 25ºC because it had negative correlation with FFA, POV and TBA value during storage except with POV at the second week of storage. This confirmed the antioxidative activity of turmeric as reported by Lim et al. (2010). This finding is in agreement with the studies by Oladosu-Ajayi et al. (2020) and Olusola (2021).

Sensory properties of freshly prepared Canned African catfish in tomato sauce

The sensory analysis compared the mean score of the commercial sample (Mackerel in tomato sauce) with African catfish in tomato sauce (Table 2). A and the comparative control had the highest mean

score for appearance (7.20) while Sample B had the lowest (6.67). There was no significant ($p>0.05$) difference in the general appearance of all samples. The percentage difference of the score for the appearance of the canned catfish for the control and the other samples (B, C, and A) are 7.36%, 3.75%, and 0.00% respectively. The comparative control had the highest mean score for colour (7.67) while Sample B had the lowest (6.20). There was significant ($p<0.05$) difference in the colour of samples B and control. However, there was no significant ($p>0.05$) difference in colour of samples A, C, and control. The percentage difference in the colour of control and other samples (B, C and A) are 19.17%, 8.74%, and 9.65%. The control ample had the highest score for taste (7.20) while Sample C had the lowest (5.40). There was a significant ($p<0.05$) difference in taste of the control sample and sample C. However, there was no significant ($p>0.05$) difference between samples B, C, and A. The percentage difference in the score of the control and the other samples (B, C, and A) are 21.25%, 25.00%, and 8.33%. The control sample had the highest score for texture (7.47) while Sample C had the lowest score (6.27). There was no significant ($p>0.05$) difference between the samples. The percentage difference between the control and the other samples (B, C, and A) are 10.71%, 16.06%, and 3.61%.

The score for overall acceptability ranged from 6.00 to 7.47. Sample D had the highest overall acceptability (7.47) while Sample C had the lowest (6.00). There was significant ($p<0.05$) difference between the control and sample C. However, there was no significant ($p>0.05$) difference between sample B, A and control. The percentage difference in the score for the overall acceptability between the control and the other samples (B, C, and A) are 8.97%, 19.68%, and 2.68%. The slightly lower score for samples containing turmeric could be as a result of the presence of curcumin and volatile component in turmeric (Lim et al., 2010) that interfered with the sensory properties the panelists are familiar with it. The lower score for texture of canned African catfish in tomato sauce compared with the commercial canned fish could be as a result of the difference in the type of fish.

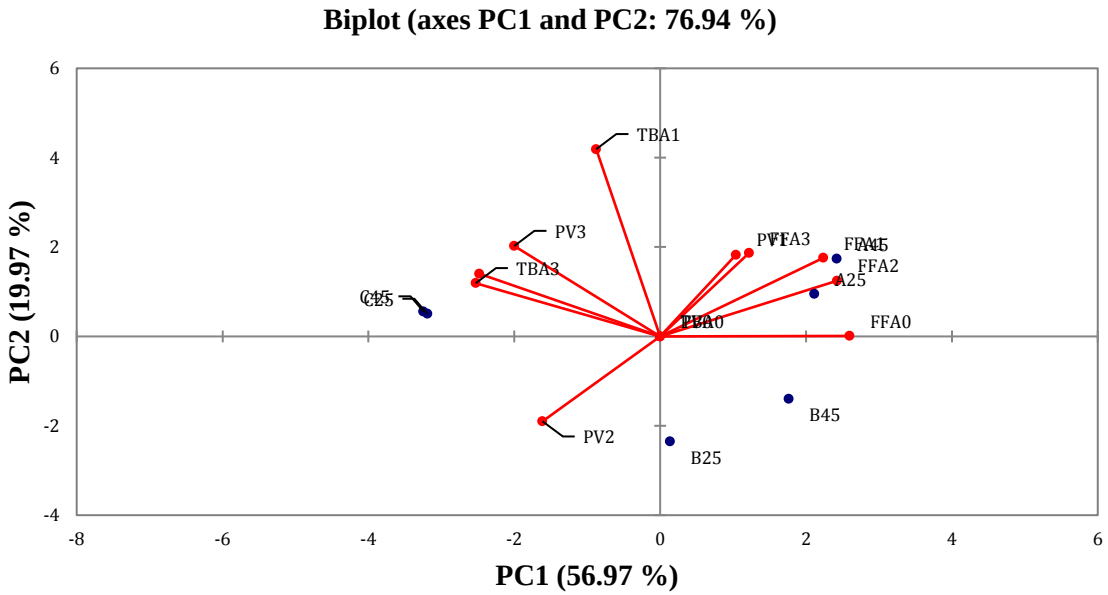

Figure 4. Biplot showing relationship between lipid oxidation of canned African catfish in tomato sauce samples. A: Canned African catfish in tomato sauce, B: Canned African catfish in tomato sauce with 3% turmeric paste, C: Canned African catfish in tomato sauce with 4% turmeric paste. The Arabic numerals 0, 1, 2, 3 indicate number of weeks.

Table 2. Sensory Assessment of freshly prepared Canned African catfish in tomato sauce

Sample	Appearance	Colour	Taste	Texture	Aroma	Overall acceptability
A	7.20±1.26^{a}	6.93±1.16^{ab}	6.60±1.45^{ab}	7.20±1.37^{a}	7.33±0.98^{a}	7.27±1.38^{ab}
B	6.67±1.44^{a}	6.20±1.26^{b}	5.67±1.39^{b}	6.67±1.34^{a}	6.67±1.79^{a}	6.80±1.21^{ab}
C	6.93±1.22^{a}	7.00±1.25^{ab}	5.40±1.12^{b}	6.27±1.44^{a}	6.33±1.29^{a}	6.00±1.60^{b}
Commercial control	7.20±1.69^{a}	7.67±1.23^{a}	7.20±1.56^{a}	7.47±1.55^{a}	7.07±1.39^{a}	7.47± 1.51^{a}

A: Canned African catfish in tomato sauce, B: Canned African catfish in tomato sauce with 3% turmeric paste, C: Canned African catfish in tomato sauce with 4% turmeric paste, Comparative control: Commercial canned mackerel in tomato sauce. Values are means of three replicates ± standard deviation. Means followed by different superscript in the same column are significantly different at $p < 0.05$

Conclusions

This research showed that addition of turmeric paste at 3% and 4% reduced microbial load thereby increasing the shelf life of fresh African catfish without having negative effect on the texture, appearance and aroma. It also reduced the rate of lipid oxidation in all the samples. Therefore, turmeric could be considered as a bio preservative along with canning in extending the shelf life of African catfish at all seasons even in the sub-Saharan Africa where the weather is extremely hot during harmattan season.

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