

RESEARCH ARTICLE

Development of ready-to-eat canned fish using rainbow runner (*Elagatis bipinnulata*) with different filling materials

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ABSTRACT

Fish is widely considered as one of the perishable food items and increasing fish shelf-life is important for avoiding post-harvest losses. The objective of the present study was to develop a ready-to-eat canned fish product using readily available relatively cheaper fish: Rainbow runner (*Elagatis bipinnulata*). The matured Rainbow runner with an average weight of 4.2 kg was utilized in preliminary trials to find out the best spice levels and filling solutions. These preliminary canned fish products were sensory evaluated with 30 untrained panelists. Based on sensory evaluation, the best filling solutions were selected to prepare the final canned fish products. These final canned fish products were sterilized at different sterilization periods (121 °C: 50, 65, 70 and 75 min). Subsequently, these final products were sensory analysed for finding the best sterilization period using the previous sensory panelists. Finally, fish products with the best filling solutions and the best sterilization period were subjected to keeping quality analysis (pH, lipid oxidation, antioxidant activity and microbial count) for 30 d and proximate analyses. Preliminary sensory analysis revealed that soy sauce and tomato sauce were the best filling solutions. Sensory analysis of the final product indicated 65 min. of sterilization period was best for fish products in both filling solutions. The proximate composition of protein, lipid and ash of the final products were relatively higher than the comparable canned products in the market. Keeping quality analyses of final products have indicated that canned products were free from *E. coli* and *Salmonella*. Lipid oxidation and total plate count were within the acceptable levels (Thiobarbituric acid reactive substance assay (TBARS) <3 mg MDA/kg and <10⁵ cfu/g, respectively). Antioxidant activity measured in terms of DPPH (2,2-diphenyl-1-picrylhydrazyl scavenging activity was high (>60%) in both products. The present study revealed that the canned Rainbow runner in soy sauce and tomato sauce can be a preferable product up to 30 d of storage period and a suitable alternative to other canned fish products in the market. Further, nutritional evaluation of these products (E.g. fatty acid analyses) and keeping quality analyses over a longer period can be recommended subject to further studies.

Keywords: Canned fish, keeping quality, lipid oxidation, rainbow runner, sensory analysis

INTRODUCTION

The fisheries sector plays a key role in human nutrition, employment, trade and economic sectors throughout the world. In 2019, the annual fish production of Sri Lanka was 505,830 metric tonnes and the contribution of the Sri Lankan fisheries sector towards Gross Domestic Production (GDP) was 1.3% (Ministry of Fisheries, 2020). Moreover, fish protein contributes to more than 50% of the animal protein requirement of people in Sri Lanka (Ministry of Fisheries, 2020). This popularity of fish as a healthy food may be driven by low cost, balanced nutrient composition, digestible protein and lipid contents and high amount of omega 3 Long-chain polyunsaturated fatty acids (n-3 LC PUFA) (Tacon and Metian, 2013).

Although there are numerous health benefits, fish is considered as one of the most perishable foods (Balachandran, 2001). Therefore, preservation is essential to maintain the quality and increase shelf-life of fish products. Various preservation methods including salting, drying, smoking, fermentation and canning can be utilized to increase the shelf life of fish products (Ghaly *et al.*, 2010).

Among all, canning is a food preservation method in which spoilage is prevented by killing the microorganisms by application of heat and chemical preservatives and enclosed in a hermetically sealed container. Canned fish products play an important role in the economy of many countries especially in developing economies (Xavier *et al.*, 2007; Bratt, 2010). Moreover, canned foods are popular among consumers as one of the ready-to-eat/ready-to-cook products. This popularity of consumption of canned products is governed by changes in human lifestyle (Bindu *et al.*, 2004), busy work schedules, women entering into the workforce and increased purchasing power of consumers (Venugopal, 2006). In the context of seafood, ready-to-eat and ready-to-cook canned products are available in various formats using the different fish types (salmon, herring, sardines, mackerel and tuna) (Prasertong, 2016).

As a consequence, much research has been conducted to find safe alternative sources for collagens. Especially fish skins including marine and freshwater fish species as well as fish collagens which have different chemical and physical properties compared to mammalian collagens have been studied (Zhang *et al.*, 2009). Collagens obtained from skins of several marine fish species have been isolated by Kittiphattanabawon *et al.* (2005). Conversely, collagen studies were rarely reported from freshwater fish except for Nile perch (*Lates niloticus*) (Muyonga *et al.*, 2004), Grass carp (*Ctenopharyngodonidella*) (Zhang *et al.*, 2007) and Channel catfish (*Ictalurus punctatus*) (Liu *et al.*, 2007).

The Canning industry uses several filling media and other additives following market demand (Balachandran, 2001). The filling medium helps improve taste, texture and flavour of the final product (Balachandran, 2001). Brine and oil are commonly used as filling media in the canned fish industry (Xavier *et al.*, 2007). Other than brine and oil, refined vegetable oil and sauce are popular filling medium

Sri Lankan canned fish industry mainly relies on imported canned fish products. In 2019, the imported canned fish production account for 36,806 metric tons while the domestic canned fish production was 2,651 metric tons (Ministry of Fisheries, 2020). The commercial canned fish production of Sri Lanka mostly depends on locally available Indian scads (*Decapterus russelli*) and imported Pacific mackerel (*Scomber japonicus*) (Ediriweera *et al.*, 2019; CFMASL, 2018). However, these two species are sporadically available and the seasonal availability of these raw materials hinders the year around canned fish production. Except that, a few authors have utilized alternative species for canned fish production (Jeewanthi *et al.*, 2018). However, these studies are not scaled up for commercial ventures. Therefore, a considerable knowledge gap exists on the potential use of other local fish species for canned fish production.

Rainbow Runner (*Elagatis bipinnulata*) is a pelagic fish species common in the Indian Ocean (FAO, 2018). Considering its nutritional value, the essential fatty acid; Docosahexaenoic Acid (DHA) level is extremely high in the muscle of Rainbow runner (Saito *et al.*, 1999). It is readily available throughout the year at a lower cost than the other fish species. These advantages enable rainbow runner as one of the best fish species in domestic canned fish production. Therefore, the objective of the present study was to develop an alternative, low cost, ready-to-eat canned fish product using a readily available fish; Rainbow runner.

MATERIALS AND METHODS

Fish sample collection

Medium-sized and matured Rainbow runner with an average weight of 4.2 kg were purchased from Galle Fishery Harbor, Sri Lanka and transported in ice containers to the Happy Cook Lanka Food (Pvt.) Ltd., Galle, Sri Lanka. Spices (chili powder, salt, pepper, coriander powder, garlic powder, turmeric powder, cinnamon powder, ginger powder, brindle berry cream, cardamom, curry leaves and pandanus leaves), soy sauce, tomato sauce and soybean oil available in the local market were used for this study. Polymer-coated tin-free- steel cans (TFS) were supplied by Happy Cook Lanka Food (Pvt.) Ltd., Galle, Sri Lanka.

Collected fish samples were de-headed; scales, fins and guts were removed and then, the samples were thoroughly cleaned using tap water. As a potential filling solution for the intended canned fish products, soybean oil, water, soy sauce and tomato sauce were selected based on the previous literature (Sadok and Selmi, 2007). A series of preliminary trials were conducted to determine the best spice level and other ingredients for intended canned fish products. Based on these trials, the final recipe used for the development of canned products is indicated in Table 1.

Table 1: Percentage composition of the ingredient used in canned fish preparation.

Ingredient	Percentage
	$\frac{\text{Fish/spice/filling solution weight}}{\text{Total weight}} \times 100\%$
Fish flesh	85.12
Chili powder	1.54
Salt	1.03
Pepper	1.03
Coriander powder	0.52
Garlic powder	0.39
Turmeric powder	0.26
Cinnamon powder	0.26
Ginger powder	0.26
Brindle berry cream	0.26
Cardamom	0.10
Curry leaves	0.10
Pandanus leaves	0.10
Filling solution	9.03

After pre-preparation, fish flesh was cut into standard pieces (3 cm thickness) along the backbone. Then, prepared fish pieces were mixed with spices, sauce and filling solutions as per the recipe described in Table 1. After that, the mixture with fish, spices and sauce was seasoned for over 20 min. Polymer coated tin fee steel cans were filled with fish pieces, filling media and spices and pre-cooking was performed. During the pre-cooking process, the temperature of the steamer was maintained at 80 – 90 °C for 20 min. Sealing of the cans was performed by the can sealing machine and subsequent heat sterilization was performed (65 min. and 121 °C).

Sensory evaluation of the preliminary canned fish products

Sensory evaluation of preliminary canned products was performed using 30 untrained taste panelists (age 21 – 30 y) consisting of both male and female. Color, texture, aroma, juiciness, mouthfeel, overall taste and overall acceptance of these products were measured using the 9-point hedonic scale (9-Like extremely and 1-Dislike extremely).

Filling media with best scored canned products in preliminary trials were selected to prepare the final canned fish products. The other ingredients used in these final canned fish products were constant as indicated in Table 1. After preparation, these products were sterilized in four different time durations (50, 65, 70 and 75 min.) at 121 °C. Finally, these different products were sensory analyzed using the previous panelists for finding the best sterilization period.

Proximate analysis of canned fish products

Based on the sensory analysis of final canned fish products, products with the best sterilization time and best filling media were analyzed for protein, lipid and ash content (AOAC, 2016).

Keeping quality analyses of canned fish

Microbiological analyses

The presence of *Escherichia coli*, *Salmonella* spp. and total aerobic microorganisms in canned fish products were determined by microbiological analyses following AOAC methods (2016). As a growth media for microorganisms, Eosin Methylene Blue Agar (EMB) for *Escherichia coli*, Xylose Lysine Deoxycholate Agar (XLD Agar) for *Salmonella* and nutrient agar for aerobic microorganism were used. Keeping quality tests of canned fish products was performed at five-day intervals (at 2, 7, 14, 23 and 30 d) over 30 d at room temperature (~25 °C).

pH Test

For sample preparation, 1 g of canned fish was blended with the 10 mL of filling solution. pH was measured by calibrated pH meter (Gondo, PL-700PV, Taiwan) (Woyewodal *et al.*, 1986). All measurements were triplicated and performed at 2, 7, 14, 23 and 30 d.

TBARS Assay

Lipid oxidation of samples was measured by 2-thiobarbituric acid reactive substances (TBARS) as described in modified method by Stalikas and Konidari (2001). TBARS value was reported as mg Malondialdehyde per kg of canned fish sample, 2500, 5000, 10,000 and 20,000 ppm – Concentrations of hydrolysates used.

DPPH Free Radical Scavenging Activity

DPPH radical (1, 1-diphenyl-2-picrylhydrazyl) was investigated using the modified method as described by Shimamura *et al.* (2014). Canned fish sample (750 µL) was mixed with 300 µL of DPPH solution and kept for 30 min. in a dark environment at room temperature (~25 °C) for incubation. All readings were performed in triplicates at 2, 7, 14, 23 and 30 d. Ascorbic acid was used as the positive control and the absorbance was measured at 517 nm using a UV visible spectrophotometer (UV-2005). The scavenging activity was calculated using the following formula,

$$\text{Scavenging activity of DPPH (\%)} = [1 - (A_s - A_1) / A_0] \times 100$$

A_s – Absorbance of the samples

A_0 – Absorbance of the pure DPPH

A_1 – Absorbance of the sample added to methanol

Statistical analysis

Sensory evaluations were analyzed using the Friedman test. Differences among treatments were considered at $P < 0.05$. A two-sample t-test was used to compare the proximate composition of final canned fish products. Results of the keeping quality analyses (microbiological analysis, pH and lipid oxidation) were analyzed using a one-way ANOVA test. A significance level of $P < 0.05$ was used to indicate the difference between storage time durations. All the analyses were performed with MINITAB 17 statistical software version 17.3.1 (Minitab® 17.3.1).

RESULTS AND DISCUSSION

Organoleptic properties- preliminary canned fish products

Based on the preliminary investigations, the canned Rainbow runner in tomato sauce and canned Rainbow runner in soy sauce showed better organoleptic properties in overall acceptance, overall taste, mouthfeel and aroma ($P < 0.05$) (Figure 1).

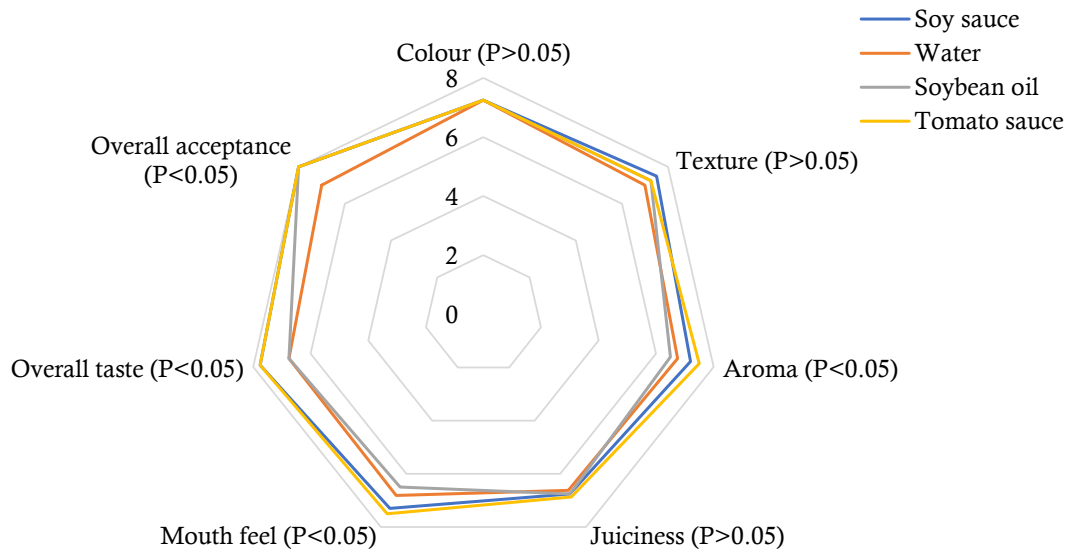


Figure 1: Radar plot of hedonic sensory evaluation for determining the best filling solution for the canned Rainbow runner (sterilization at 121 °C; 65 min).

For both filling solutions (soy sauce and tomato sauce) preferable sterilization time duration was 65 min. (Figure 2a and 2b). The organoleptic properties of the Rainbow runner in tomato sauce indicated that there were significant ($P<0.05$) differences in colour, texture, juiciness, mouthfeel, overall taste and overall acceptance in all treatments sterilized at different sterilization periods. (Figure 2a). However, Rainbow runner in soy sauce filling solution indicates no significant ($P>0.05$) difference for any of the organoleptic properties under various sterilization time durations (Figure 2b). Based on these sensory results, it can be concluded that canned fish products in both soy sauce and tomato sauce filling media and sterilized at 65 min. were the best products.

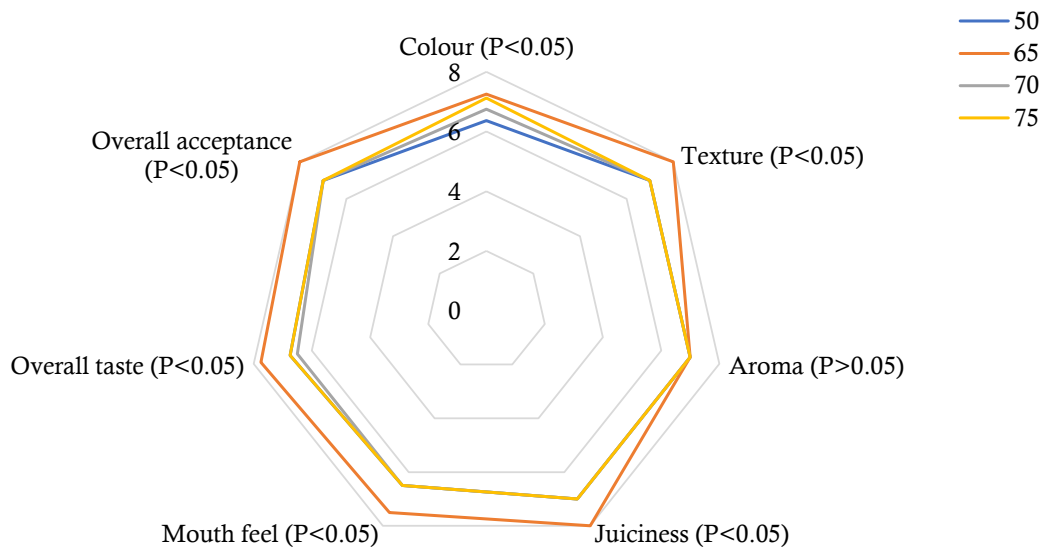


Figure 2a: Radar plot of hedonic sensory evaluation for filling solution of tomato sauce at different sterilization periods (sterilization temperature 121 °C).

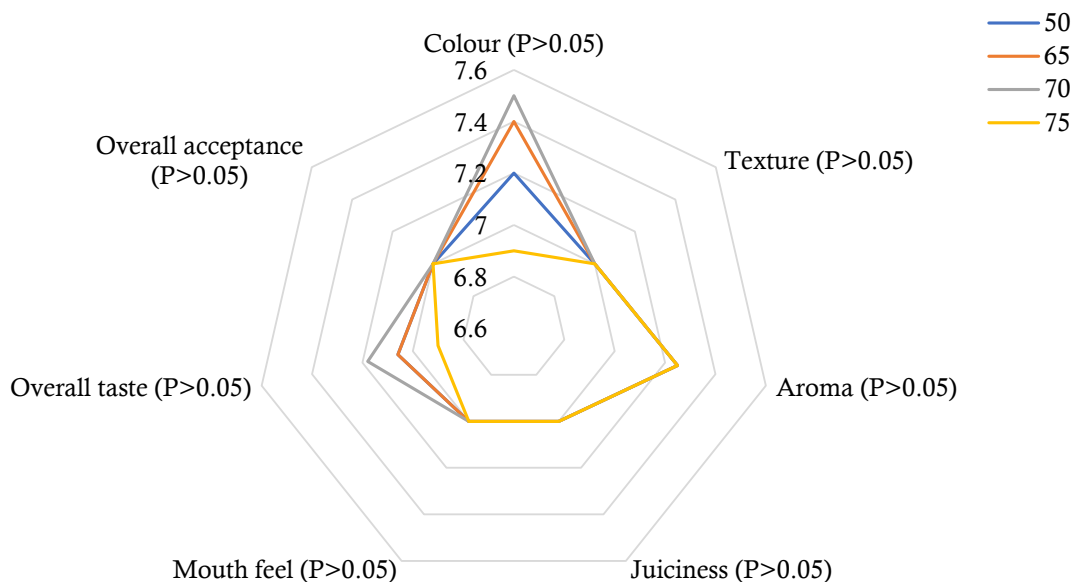


Figure 2b: Radar plot of hedonic sensory evaluation for filling solution of soy sauce at different sterilization periods (sterilization temperature 121 °C).

Organoleptic properties - final canned fish products

Enzymatic hydrolysis of protein is a process of decomposition of protein into individual amino acids and/or peptides that occur with the participation of enzymes (Eckert, 2013). This is one of the hydrolysis processes used to produce fish protein hydrolysates (FPHs). The degree of hydrolysis is an important factor and it determines the terminal peptides and bioactivity (Barzideh *et al.*, 2014). In this study, collagen was hydrolysed using pepsin, trypsin and protease enzymes at 37 °C for 0, 3, 6, 9, 12 and 24 h and the best time lag for the prepared collagen hydrolysates was selected from each enzyme treatment using the physical appearance of the produced collagen hydrolysates and 15% SDS-PAGE gel electrophoresis visual observations (Table 1).

Proximate analyses of canned fish products

The results of the proximate analysis of canned fish products are given in Table 2. There was no significant ($P>0.05$) difference between the two products in terms of ash, lipid and protein contents. Protein is the most important constituent of fish which determines its nutritional quality (Balachandran, 2001). Generally, fish contains 15-26% and protein content and it is reduced with processing (Aberoumand, 2011). Although there was no significant ($P>0.05$) difference in the protein content of the two prepared canned fish products, the protein content in the Rainbow runner in tomato sauce is higher than that of soy sauce. However, these variations of protein content in both canned products may be several factors since fish protein content depends on several biological factors (E.g. sex, age and growth stage).

Table 2: Proximate composition of final canned fish products.

Proximate analysis	Rainbow runner fish canned in tomato sauce (%)	Rainbow runner fish canned in soy sauce (%)	Chilean jack mackerel (Bastías <i>et al.</i> , 2017) (%)
Ash	2.35±0.55	3.37±0.41	0.98±0.15
Lipid	6.59±0.28	6.52±0.18	4.65±0.66
Protein	26.91±3.69	19.92±0.34	25.45±0.05

The ash content of both products represents the inorganic residues (E.g. minerals) in the final products. The ash content of both products was below the values as reported by Elshehawy and Farag (2019) in a similar canned product made with various species of tuna and sardines. The lipid content in both prepared canned products was below the value (~23%) as reported by Aberoumand (2011). However, the nutrient composition of the final canned fish products in the present study was comparable with the more prominent canned fish products made out of Chilean jack mackerel (*Trachurus murphyi*) (Table 5). This similarity may be attributed to both Chilean jack mackerel and Rainbow runner belonged to the same family (Carangidae) which may drive their nutritional composition (Vaitla *et al.*, 2018). From a nutritional perspective, Rainbow runner in both tomato sauce and soy sauce media are rich in major nutrients and potential alternatives for imported canned products.

pH Test

During the 30 d of storage time, the pH of the canned product with soy sauce ranged from 5.65 ± 0.11 to 5.75 ± 0.06 . The pH of the canned product with tomato sauce ranged from 5.59 ± 0.15 to 5.64 ± 0.06 (Table 3). There was no significant ($P > 0.05$) difference in pH in different storage periods. The low acidic pH values in both products may be due to the filling media of tomato sauce (~5.32) and soy sauce (4.40-5.40) which has slight acidity values (Arrow Scientific, 2013). Although the overall pH value of the samples is slightly above 4.6 which may carry *Clostridium botulinum* spores, the pre-cooking and canning process ensures the suitability of the product which indicates the destruction of *Clostridium botulinum* spores (McGlynn, 2016). During 30 d of storage time, the pH of both canned fish products was within the prescribed pH range for human consumption prescribed by the Sri Lanka Food Act (SLFA, 1980).

Table 3: Changes of the mean pH value of canned Rainbow runner in filling solutions of tomato sauce and soy sauce during the 30-days storage period.

pH value	Storage time (d)				
	2	7	14	23	30
Rainbow runner in tomato sauce	5.59 ± 0.05	5.61 ± 0.03	5.59 ± 0.04	5.60 ± 0.04	5.64 ± 0.06
Rainbow runner in soy sauce	5.65 ± 0.11	5.75 ± 0.08	5.68 ± 0.02	5.66 ± 0.02	5.75 ± 0.06

Some antioxidant compounds are good radical scavengers while some others are effective lipid peroxidation inhibitors (Barzideh *et al.*, 2014). Therefore, different antioxidant assays are required to evaluate antioxidant capacity of collagen hydrolysates. In previous studies, collagen and gelatin hydrolysates from different sources showed antioxidant activities (Kim *et al.*, 2001; Mendis *et al.*, 2005). In the present study, the antioxidant activity of *P. pardalis* skin collagen hydrolysed with pepsin, trypsin and protease enzymes in 0 h incubation period at 37 °C was evaluated using DPPH free radical scavenging activity assay and Thio-Barbituric Acid Reactive Substances (TBARS) assay.

Microbiological Analysis

During the 30 d of storage time, the samples were free from *E. coli* and *Salmonella* spp. Ready-to-eat food products should be free from *E. coli* and *Salmonella* spp. because these pathogens indicate possible faecal contamination and poor hygienic conditions (Tharaka *et al.*, 2016). These microorganisms are heat sensitive. The absence of the microorganism in canned fish products in the present study may be attributed to the higher temperature used in the sterilization process in the canning. The total Plate Count (TPC) of the canned product in soy sauce ranged from 6.36 ± 0.18 log cfu/g - 7.36 ± 0.22 log cfu/g. TPC of the canned product in tomato sauce ranged from 6.30 ± 0.17 log cfu/g - 7.87 ± 0.05 log cfu/g (Table 4). In both filling solutions, colony count increased from the 2nd day to the 30th day. Rainbow runner in tomato sauce exhibited a significantly ($P < 0.05$) higher colony count on the 30th day. Similarly, Rainbow runner product in filling solution of soy sauce exhibited significantly ($P < 0.05$) higher values at both 23rd day and 30th day of the period. Overall, the TPC level in the present study was much higher compared to

the study on the microbial level of canned meat products (Oranusi *et al.*, 2012). However, recorded TPC values in the current study were still below the maximum permissible limit (10^5 cfu/g) of SLS (Tharaka *et al.*, 2016).

Table 4: Changes in the colony count of the canned Rainbow runner in tomato sauce and soy sauce filling solutions during the 30-day storage period.

Colony count (log cfu/g)	Storage time (d)				
	2	7	14	23	30
Rainbow runner in tomato sauce	6.30±0.17 ^c	6.61±0.03 ^c	7.17±0.04 ^b	7.53±0.12 ^{ab}	7.87±0.05 ^a
Rainbow runner in soy sauce	6.36±0.18 ^c	6.42±0.06 ^{bc}	7.08±0.05 ^{ab}	7.30±0.17 ^a	7.36±0.22 ^a

TBARS Assay

TBARS values indicate the lipid oxidation of foods (Fernandez *et al.*, 1997). Lipid oxidation is a major cause of deterioration in the quality of food and it limits the shelf life of fresh food and food products. Lipid oxidation in foods occurs with a complex chain of reactions. At the initial step, there are more primary products (peroxides) followed up by secondary oxidation products (aldehydes, ketones, epoxides, hydroxy compounds, oligomers, polymers, hexanal or Malondialdehyde (MDA)). These secondary products provide undesirable sensory and biological effects in the food products (Barriuso *et al.*, 2013). Oxidation causes off flavours, loss of colour, altered nutrient value and health risk for consumers (Ahmed *et al.*, 2016). TBARS values related to a Rainbow runner product in tomato sauce varied between $0.04±0.17$ - $0.07±0.02$ mg MDA/kg. The TBARS values of Rainbow runner fish product in soy sauce varied between $0.01±0.009$ - $0.06±0.006$ mg MDA/kg (Table 5). The reported TBARS values in the present study for both canned fish products were lower than the recorded value ($1.94±0.21$ mg MDA/kg) for canned *Sardina pilchardus* in tomato sauce (Sadok and Selmi, 2007). Previous studies have reported that TBARS values of canned fish products may depend on storage time, sterilization temperature, fatty acid composition, filling medium and species used in the product (Ahmed *et al.*, 2016, Medina *et al.*, 1998, Kong *et al.*, 2008). For both canned fish products, the highest TBARS values were reported on the 14th day of the storage period. Fish is considered one of the best sources for Poly-Unsaturated-Fatty acids (PUFA). Oxidation of PUFA in both canned products may be attributed to the elevated MDA amount on the 14th day. The consequent reduction of TBARS during the 23rd to the 30th day of the period may be caused by the interaction of MDA with spices which contain a considerable amount of antioxidant. This may lead to limited free MDA to react with TBA (Kannaiyan *et al.*, 2016). During the whole 30 d of storage, the average TBARS values in both samples (Rainbow runner in tomato sauce; $0.12±0.008$, Rainbow runner in soy sauce; $0.13±0.008$ mg MDA/kg) were lower than the 3 mg MDA/kg. TBA value <3 mg of MDA/kg is considered as perfect materials for human consumption (Connell, 1990).

Table 5: Changes of the mean Malondialdehyde amount/TBARS values of canned Rainbow runner product in filling solutions of tomato sauce and soy sauce during the 30-d storage period.

Malondialdehyde amount (mg MDA/kg)	Storage time (d)			
	7	14	23	30
Rainbow Runner in tomato sauce	0.04±0.17 ^b	0.27±0.02 ^a	0.13±0.008 ^b	0.07± 0.02 ^b
Rainbow Runner in soy sauce	0.01±0.009 ^c	0.31±0.01 ^a	0.14±0.18 ^b	0.06±0.006 ^c

*Values in the same row with different superscript letters are significantly different ($P<0.05$)

DPPH radical scavenging activity

DPPH scavenging activity is one of the efficient and quick methods for determining antioxidant activity (Cui *et al.*, 2004). In biological systems, free radicals and reactive oxygen species usually cause oxidative damage of protein, DNA and lipids which lead to many chronic diseases. Antioxidants in food products can scavenge the DPPH radicals which may provide the quantitative measurement of the antioxidant in a food product (Gangwar *et al.*, 2014). DPPH scavenging activity in the Rainbow runner products in soy sauce and tomato sauce have increased from the 2nd to the 30th day's storage period (Table 6). During the 30-d storage period, there was no significant ($P>0.05$) difference in scavenging activity of the canned fish product in soy sauce. In contrast to that, significantly ($P<0.05$) higher DPPH scavenging activity was recorded for the Rainbow runner product in tomato sauce on the 30th day. Increased antioxidant activity of canned fish products may change with increased storage time (Roe *et al.*, 2013). As a whole, free radical scavenging activity was high in both samples and the average DPPH activity for both products were over 60%. In the preservation of foods, food additives rich in antioxidants are used to prevent oxidative rancidity (Shimamura *et al.*, 2014). In the present study, spices like pepper, cinnamon, ginger and bridle berry cream were added to both canned fish products. Pepper is one of the effective antioxidants and it is important to prevent and reduce oxidative stress (Meghwal and Goswami, 2012). Ginger, cinnamon, coriander and brindle berry cream also have antioxidant activity (Shivakumar, 2013; Axe, 2018, Clark, 2018). Moreover, soy sauce and tomato sauce have high antioxidant activity (Domínguez *et al.*, 2020; Wang *et al.*, 2007). Therefore, the antioxidant activity of spices and sauces in both canned products may cause a high level of radical scavenging activity. Although the presence of antioxidants may cause off-flavours in some of the food products (Wilson *et al.*, 2017), sensory analysis indicates the suitability of the product for consumer consumption in the current study.

Table 6: Changes of the DPPH activity (%) of canned Rainbow Runner products in filling solutions of tomato sauce and soy sauce during the 30-d storage period.

DPPH Scavenging activity (%)	Storage time (d)				
	2	7	14	23	30
Rainbow Runner in tomato sauce	65.44±0.60 ^c	76.99±3.55 ^{ab}	79.53±2.68 ^{ab}	70.71±1.9 ^{bc}	81.67±1.03 ^a
Rainbow Runner in soy sauce	65.91±1.30	66.44±0.40	69.82±3.25	67.85±1.56	72.22±2.02

*Values in the same row with different superscript letters are significantly different ($P<0.05$)

CONCLUSIONS

The current study has indicated the potential of using the Rainbow runner in canned fish production in Sri Lanka. Sensory analysis and keeping quality analysis indicated that, during 30 d of storage time, the Rainbow runner in both tomato sauce and soy sauce filling media were suitable for human consumption. This study can be extended to find out the suitability of the product for longer storage time. Moreover, analysis of the fatty acid composition of the current products (especially n-3 PUFA) may provide further nutritional information.

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