

## Development of Ready to Eat Fish Paste Using Chub Mackerel (*Scomber japonicus*) Tail Offcuts

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### ABSTRACT

**Purpose:** The *Scomber japonicus* (Chub mackerel) is one of the popular marine fish species used in canning industry yet the production of fish tail offcuts during canning process considered as a waste leaving the significant loss to the manufacturer. The present study was focused on the development of a ready to eat fish paste using chub mackerel tail offcuts.

**Research Method:** Fish paste was prepared using three (03) different recipes. Minced fish tail offcuts were incorporated at 63.5, 51.1 and 61.1% with spices and other ingredients added accordingly. To find the best recipe for chub mackerel, physicochemical properties, definite sensory attributes, stability and the safety of the fish pastes were examined.

**Findings:** Recipe 03 incorporated with 61.1% of minced fish had the highest overall acceptability together with maximum scores for flavour, colour and texture. Further, recipe 03 had the highest crude protein and lowest crude fat percentage. The pH of all fish pastes shown to have a significant reduction during the first 08 weeks nevertheless the values were within the acceptable level. Lowest free fatty acid content was also detected in recipe 03 while peroxide value was insignificant in all the recipes. Moreover, *Clostridium botulinum* was not detected in fish pastes which assured the safety of the end product during 08 weeks of storage at room temperature.

**Research Limitation:** The shelf life of the prepared fish pastes were not tested for a longer period.

**Originality/Value:** Chub mackerel tail offcuts can be successfully used to produce a ready to eat fish paste as a value-added fish product while minimizing the waste of edible by-products.

**Keywords:** Fish paste, Offcut, *Scomber japonicas*

### INTRODUCTION

Seafoods including fish are highly perishable in nature and easily become unsuitable for human consumption and perhaps dangerous to health due to the number of reasons including microbial development, chemical alterations and breakdown by endogenous enzymes (Wang *et al.*, 2017). Throughout the world, more than 27% of fish is lost or wasted between landing and consumption (Badonia *et al.*, 1988). Therefore, post-harvest handling and transportation of fish require excessive care in order to maintain the quality and nutritional attributes (Huss *et al.*,

1998).

Fish canning is one of the processing methods of aquatic products which enables the extending shelf life thus making it less expensive during storage and other aspects of distribution

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(Myrseth, 1985). Fish canning process provides sterilization by applying sufficient heat to destroy microorganism and also prevents invading them into the end product (Sampels, 2015). However, there are some inherent problems in the canning process that may alter the stability and flesh disintegration which would affect the delicate flavour and texture of the end product. Besides, leach out of vitamins and proteins into cooking media are identified as the primary sources of loss of nutrients (Abraha *et al.*, 2018).

In 2018, the global canned seafood market was estimated as USD 22.57 billion and it has been further increasing and projected to reach USD 29.14 billion in 2026. In addition to the durability as a ready to eat product, inexpensive nutritional properties of it have also been driving the market. Canned fish in Sri Lankan context is considered as one of the major imported fishery products that contributed about 38% (40,000 Mt) of the total share and 28% (9,500 million LKR) of total import value in 2017. In order to minimize the reliance on importation, the ministry of fisheries facilitated the private sector to enter the canning fish industry. The first fish canning factory was established in Galle in year 2012 with the capital investment and daily production capacity of Rs.840 million and 10,000 of cans, respectively. Subsequently, another company started a canned fish factory in Paliyagoda with the capital investment of Rs.170 Million and daily production capacity of 24,000 cans respectively (MFAR, 2015). With the development of the fish canning industry in Sri Lanka, 4.8 million cans were produced during the year 2017 (NARA, 2017).

However, in fish canning process, significant amount of offcuts have been produced and left unusable due to small size and the presence of bone particles. According to Arvanitoyannis and Kassaveti 2008, 1000 kilograms of filleting of de-headed white fish can produce up to 200-300 kilograms of offcuts and frames as solid waste. Hence, preparation of value-added products such as mince or mince-based products could be the best way of using these edible leftovers (Bae *et al.*, 2007; Datta, 2013; Ghaly *et al.*, 2013; Dhanapal *et al.*, 2016).

Fish paste is one of the instant value-added canned products which is manufactured by using cooked fish mechanically broken down through various processing steps until it reaches the consistency of a paste (Montagne, 2003). Fish pastes represent a considerable portion of the protein intake of many people in Asia – Pacific region (FAO, 2015), especially by the poorest sections of the population. Besides, fish offcuts could be used for producing fish paste as a ready to eat fish product.

Chub mackerel is one of the migratory pelagic species which inhabit in both tropical and temperature areas including Indian, Atlantic and Pacific oceans. Chub mackerel carnivorous fish, primarily feed on small fish squids, copepods, and other crustaceans. It can reach up to 64cm in body length (average length = 30cm) and a maximum weight of 2.9kg (Hernández and Ortega, 2000).

As explained by Arvanitoyannis and Kassaveti (2008), the authors have also found that 9.5% (95g out of 1kg) of chub mackerel (*Scomber japonicus*) tail offcuts were produced as leftovers. This tail offcuts were produced due to ununiform size since 70% of the fish coming to the processing factory do not have the standard size which is 250 mm. This production of offcuts significantly affects the net profit of the company since they have estimated the loss is Rs 2,106,760.00 per month even after selling them for bakery purposes at a low price.

Therefore, the present study was aimed to develop thermally processed ready to eat fish paste using chub mackerel (*Scomber japonicus*) offcuts. Further, it aims to study the quality attributes including physicochemical and sensory properties, stability and the safety of the formulated fish pastes.

## MATERIALS AND METHODS

Chub mackerel tail offcuts (average length = 3-4 cm) were used for the preparation of fish pastes. These tail offcuts were produced due to ununiformed fish which cannot be entirely used for the canning process. Spices and other

ingredients used for the recipe development were collected from the local market in Galle, Sri Lanka. Polymer-coated tin-free steel (TFS) small cans (volume = 200 ml) were used as the containers and preparation was done in the fish can processing line with slight modifications.

### Recipe development

Three (03) recipes were used for the preparation of fish paste, in which two recipes (recipe 01 and recipe 02) previously developed for Tilapia (*Oreochromis mossambicus*) (Dhanapal *et al.*, 2016) and Pink Perch (*Nemipterus japonicus*) (Datta, 2013) were replaced with chub mackerel up to 63.50% and 51.10% respectively. Recipe 03 was primarily developed for chub mackerel during this study via conducting a series of preliminary trials. Spices used in recipe 03, were based on preferences of the local taste.

### The fish paste production process

The tail offcuts were initially washed using the compartment sink to remove blood and dirt. After washing, offcuts were dipped in 20% brine solution for 5 minutes. Containers were filled with offcuts with water and precooked the content at 80°C to 90°C for 20 minutes. Subsequently, water was drained out and deboning was done manually. Spices and other ingredients were added and blended using the electrical blender. The mixture was filled into empty cans and

sealed using seamer machine. Sealed cans were thoroughly washed and retorting was done at 121°C and pressure 0.9kg/cm<sup>2</sup> for 55 minutes.

### End product evaluations

During end product evaluations, three replicates (r=3) were used in each treatment (recipes/fish pastes) representing the same batch to avoid batch variations. An imported fish paste prepared using Yellowfin tuna (*Thunnus albacares*) taken from the market was used as the reference sample.

### Proximate analysis and colour determination

General parameters such as moisture, dry matter (DM), ash, crude protein (CP) and crude fat (CF) were analyzed (AOAC, 1995). The colour properties such as lightness (L\*), redness (a\*), and yellowness (b\*) were measured using Chroma meter CR-400 Konica Minolta (Tharaka *et al.*, 2016). All the measurements were taken on wet basis (% wet basis).

### Determination of sensory attributes

Sensory attributes i.e. colour, texture, flavour, odour, spreadability and overall acceptability were tested using untrained panellist (n=30) at the age between 21-55 and data were analyzed using a 9-point hedonic scale.

**Table 01: Different ingredients (%) used for the development of the recipes**

Ingredients (%)	Recipe 01	Recipe 02	Recipe 03*
Fish mince (Chub mackerel)	63.50	51.10	61.08
Sunflower oil	11.50	-	-
Coconut oil	-	24.00	14.10
Butter	-	10.40	-
Water	9.25	-	17.30
Salt	1.80	1.46	0.91
Corn flour	-	-	2.44
Spices and other ingredients	13.95	13.04	4.17
Total	100.00	100.00	100.00

\*As the recipe developed here is to be patented, exact proportions of the ingredients are not disclosed here.

## Determination of shelf-life

### Determination of pH

Homogenized solution was prepared for pH determination by mixing fish paste (5g) with 45 ml of distilled water (Kolade 2015). pH was measured using a pH meter (HQ 40d) at 7-day intervals during the storage period of 8 weeks at ambient temperature.

### Determination of rancidity

Hydrolytic rancidity and oxidative rancidity were determined via measuring free fatty acid (FFA) and peroxide values (PV) respectively (AOCS, 1998). A required fat for the experiment was obtained via Soxhlet extraction.

$$\text{FFA value} = \frac{\text{volume of sodium hydroxide} * \text{strength of sodium hydroxide} * 28.2}{\text{Sample weight}}$$

$$\text{PV [meq/Kg]} = \frac{(S - B) * N \text{ thiosulfate} * 1000}{\text{Sample weight}}$$

Where, S = titrated value of sample, B= titrated value of blank, N = normality

### Microbial evaluation – Detection of *Clostridium botulinum*

Microbiological test for the detection of *C. botulinum* was conducted after 08 weeks storage period at ambient temperature to assure the safety of the final product at Medical Research Institute (MRI), Colombo, Sri Lanka.

### Statistical Analysis

Data analysis was done using SAS 9.0 version. One-way ANOVA was used to compare means of proximate analysis and colour determination. Sensory data was analyzed using the Friedman test of Minitab 16 software. Two-way ANOVA was conducted to determine the pH, FFA and PV. Duncan's multiple range test was used to determine the differences between treatment means. Graphical illustrations were done using Microsoft Excel 2010.

## RESULTS AND DISCUSSION

### Proximate analysis

#### Moisture content

As shown in Figure 01, the highest moisture content was detected in the reference sample (65.24%) whereas the lowest was in recipe 02 (59.78%). However, the moisture content was not significant ( $p > 0.05$ ) amongst the tested recipes. The highest moisture content in the reference sample was probably due to the addition of white wine vinegar and water respectively. During the preparation, the high percentage of water (17.3%) was added to the recipe 03 could be the reason for its high moisture content compared to the other recipes. Ha *et al.* (2001) reported that moisture content affects the hardness of the fish paste. According to Adawyah (2008), fish paste can contain moisture around 35-50%, if the paste is prepared only pounded with salt. Water content in fish paste often determines its nutritive value and taste. Hence, a significant loss of moisture under the drying condition (Precooking stage; 80-90 °C) caused to loss of volatile substances, which contained in fish and also those produced during the thermal process (Anggo *et al.*, 2015). Even the precooking process can lead to a reduction of moisture in mackerel fish (Sreenath, 2007). It is suggested that adding water as an ingredient would help to retain the optimum water content in the final product. Further, stability and shelf life of the end product also depend on the water activity for instance, it is vital for microbial growth and autolysis (Isengard, 2001).

#### Ash content

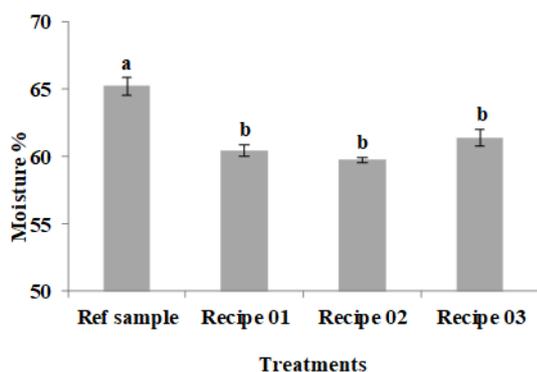
Ash content refers to the remaining inorganic residue after being ignited or oxidized of organic matter in a given food sample. It is also an important attribute for determining the quality of food ingredients (Ismail, 2017). Ash content generally represents the mineral of the prepared fish pastes. According to Figure 02, reference sample showed the lowest ash content (1.58%) ( $p < 0.05$ ). Ash content of chub mackerel fish muscles was found to be 1.50% (Lall, 1995) and a minimum of 1% in salted chub mackerel fish

products (Doe, 1998). According to (Lall, 1995), processed fishery product has a higher value of sodium content than raw muscle due to adding salt during processing. Therefore, high mineral content in developed fish pastes could be due to addition of salt and particularly in recipe 02 (2.98%) ( $p < 0.05$ ) due to incorporation of butter (10.4%) which contains 2% of salt.

### Crude protein content

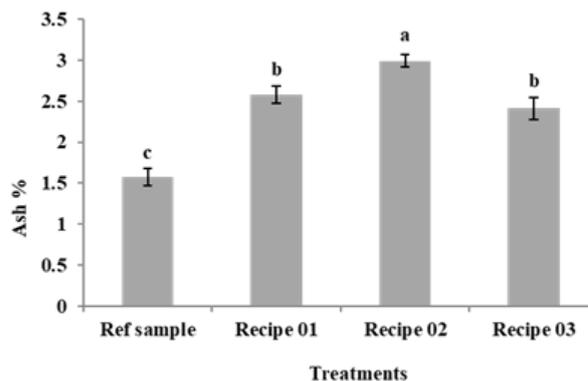
There was no significant difference ( $p > 0.05$ ) observed in crude protein content (CP) between the treatments (see. Figure 03). The lowest CP content ( $p < 0.05$ ) was found in the reference sample (12%) and could be due to addition of filler agents nevertheless the highest CP

percentage was in recipe 03 (16.89%). According to the Oyelese (2007) and Moon *et al.* (2009), chub mackerel muscle contains 18-19% protein (% wet basis) yet, it can depend on many factors including the stage of growth, season, sex etc. (Celik, 2008; Shim *et al.*, 2017). The protein content (dry basis%) in fish paste ranged from 47.78 to 57.55% for Salmon paste, 49.12% to 56.07% for Herring paste and 42.66% to 53.32% for Anchovy paste (Khater and Farag, 2016). Although several studies recorded approximate protein percent in various fish products (Naila *et al.*, 2011; Adeyeye *et al.*, 2016). The low protein content of the fish products could be attributed to the processing conditions and the time of fish harvest (Kristinsson and Rasco, 2000; Rezaei and Hedayatifard, 2013).



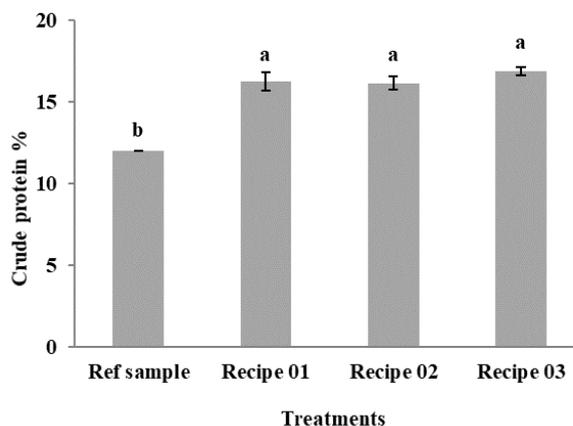
Results are expressed as mean  $\pm$  standard error of three replicates and error bars with alphabet letters designate significant difference ( $p < 0.05$ ).

**Figure 01: Moisture content of Recipe 01, 02, 03 and Reference sample.**



Results are expressed as mean  $\pm$  standard error of three replicates and error bars with alphabet letters designate significant difference ( $p < 0.05$ ).

**Figure 02: Ash content of Recipe 01, 02, 03 and Reference sample.**



Results are expressed as mean  $\pm$  standard error of three replicates and error bars with alphabet letters designate significant difference ( $p < 0.05$ ).

**Figure 03: Crude protein (CP) content of Recipe 01, 02, 03 and Reference sample.**

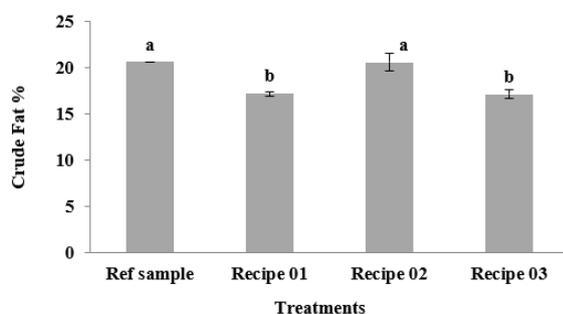
### Crude fat content

As shown in Figure 04, significant difference ( $p < 0.05$ ) was observed in crude fat content among reference sample, recipe 01 and 03 respectively. The highest crude fat (20.6%) was observed in the reference sample whereas the lowest (17.10%) observed in recipe 03. According to (Dhanapal *et al.*, 2016), fat content in Tilapia fish paste was  $13.35 \pm 0.04\%$  however, using the same recipe (recipe 01) for chub mackerel gave the high-fat percentage (17.18%) due to high crude fat content (18.62%) in cub mackerel fish muscles (Bae and Lim, 2011). Moreover, high-fat content in the recipe 02 might be due to the addition of butter and coconut oil.

Thermal treatment during the canning process has a great impact on oxidizing nutrients including vitamins and lipids. Moreover, heating is also responsible for leaching out of water-soluble nutrients i.e. proteins, minerals and vitamins. This could be further increased if the canning is carried out in oily media since, denatured proteins due to the heating process could release a considerable amount of water into the can headspace (Roe *et al.*, 2013).

### Colour Determination

The colour values of the end products were measured using three criteria i.e. lightness, redness and yellowness. There was a significant difference ( $p < 0.05$ ) observed in the lightness



Results are expressed as mean  $\pm$  standard error of three replicates and error bars with alphabet letters designate significant difference ( $p < 0.05$ ).

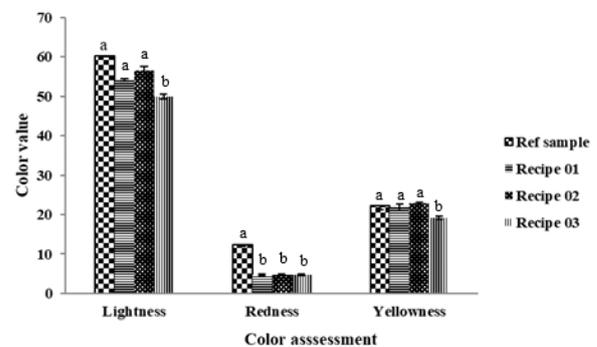
**Figure 04:** Crude fat (CF) content of Recipe 01, 02, 03 and Reference sample.

value between recipe 03 and other treatments. However, the highest lightness value ( $60.19 \pm 0.07$ ) was expressed in a reference sample prepared using Yellowfin tuna.

High lightness value in all treatments due to leaching of white connective tissue contains collagen located between muscle segments. Precooking process caused to increase in lightness value of mackerel meat besides, incorporation of other ingredients in bread-spread fish paste particularly the addition of chili powder (Tharaka *et al.*, 2016). The highest redness value ( $12.30 \pm 0.2$ ) was detected in reference sample whereas the lowest value ( $4.65 \pm 0.32$ ) was found in recipe 01 claiming the redness value of chub mackerel fish muscles higher than the white muscle (Tharaka *et al.*, 2016). Highest yellowness value ( $22.80 \pm 0.50$ ) was detected in recipe 02 while the lowest ( $p < 0.05$ ) in recipe 03 ( $19.12 \pm 0.78$ ).

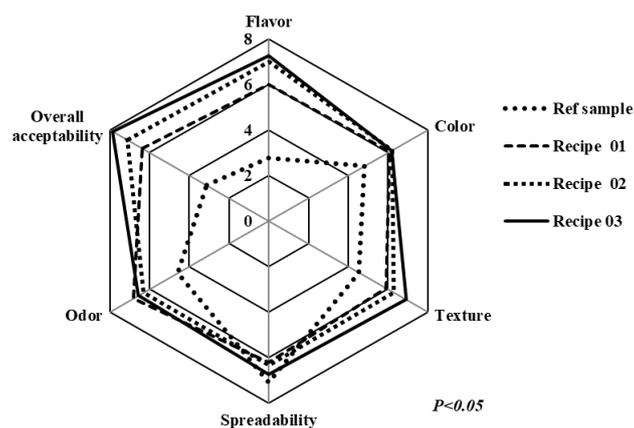
### Evaluations of sensory attributes

To determine the best recipe for chub mackerel fish paste, a sensory evaluation was conducted. Following sensory attributes i.e. colour, texture, spreadability, odour and the overall acceptance were measured. A fish paste available in the market was used as the reference sample. Sensory evaluation is an important method for valuation of freshness and quality attributes in fish processing. A product cannot be marketed unless sensory analysis results are acceptable (Uzunlu and Yildirim, 2003).



Results are expressed as mean  $\pm$  standard error of three replicates and error bars with alphabet letters designate significant difference ( $p < 0.05$ ).

**Figure 05:** Lightness, redness and yellowness of developed fish pastes.



**Figure 06:** Sensory attributes with the attained values of the Recipe 01, 02, 03 and Reference sample

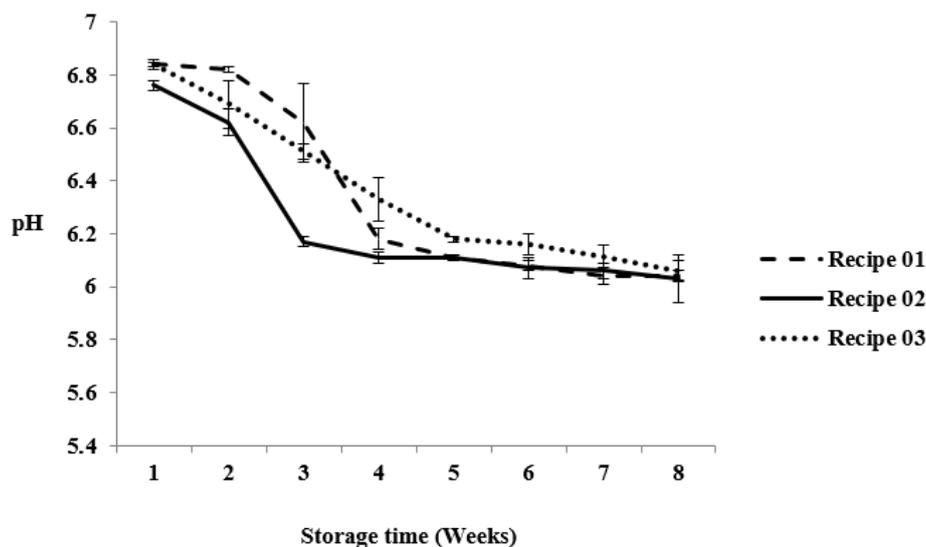
As a result of high temperature, heat-sensitive nutrients can be altered thus; nutritional and sensory attributes could be demoted due to formation of undesirable compounds (Aberoumand, 2014; Mesías *et al.*, 2015). All the tested sensory attributes showed significant ( $p < 0.05$ ) differences among treatments. As shown in the Figure 06, recipe 03 was ranked as the best but for spreadability. In contrast, lowest scores were obtained by the reference sample. Some of the ingredients used in the preparation of the reference sample such as mayonnaise, xanthan gum, egg yolk and sunflower oil could be the reason for its maximum spreadability. Overall acceptability of the product signifies the market potential. Hence, recipe 03 seemed the best compared with others. However, concerning its spreadability which is considered as one of the main attributes in the final product, it needs to be improved. The flavouring agents such as black pepper and garcinia used for recipe 03 might be the reason for its highest acceptability as described by Nair (2011) and Massullo *et al.* (2008) respectively.

### Determination of shelf life

It was reported that the ingredients used, microbiological load, hygienic conditions and formation of undesirable products during processing affected the shelf life of fish product (Kaba *et al.*, 2012; Aberoumand, 2014).

### Determination of pH

The pH test is one of the methods used to determine the deterioration of the fish muscle. According to Figure 07, all the fish pastes expressed the rapid declining of pH during the first 4 weeks. However, from 5 weeks onwards the rate of declining pH was decreased and finally stabilized. According to Anggo *et al.* (2015), pH determines the fermentation process carried out by the various microorganisms. Throughout the fermentation process pH increases however, it tends to decline at the end (Adawya, 2008). Further, research result of Zeng *et al.* (2014), reported that pH value declined lower than 4.5 due to high acidifying nature of Chinese traditional fermented whole fish product which contained less amount of salt. The pH decline of the fish paste can also be due to lactic acid formation which could probably occur a result of lipolytic rancidity in butter and promotes lipid oxidation with increasing storage time (Huss, 1995). Added ingredients such as lemon and garcinia can also be the reason for pH reduction due to the acidic nature of those ingredients. Further, these generated results are compatible with the previous studies conducted for Tilapia fish paste by Dhanapal *et al.* (2016) and Illangakoon *et al.* (2015) respectively.



**Figure 07:** Changes of mean pH values of chub mackerel fish pastes during 8 week of storage at ambient temperature.

#### ***Determination of Hydrolytic Rancidity -Free Fatty Acid (FFA) value***

According to the international association of fish meal and oil manufacturers permissible limit of FFA value of crude fish oil was 1-7% (Bako, 2017). As shown in Table 02, recipe 03 had the lowest FFA value at day 60 ( $3.57 \pm 0.33$ ) whereas recipe 02 had the highest ( $4.88 \pm 0.32$ ). Hence all the developed fish paste is within the allowable limit of FFA. High FFA value in recipe 02 might be due to incorporation of ingredients rich in fats such as coconut oil (24%) and butter (10.4%). Free fatty acids accumulation during storage and processing has a great impact on the quality of the final products including the shelf life (Koning and Mol, 1991). The presence of FFA primarily affects for the textural modifications of the product via association with proteins. It is thought to be the effect of FFA on myofibrillar proteins yet the mechanism behind this process has not been revealed (Bernárdez *et al.*, 2005).

#### ***Determination of Oxidative Rancidity – Peroxide Value (PV)***

According to the codex general standard (1999), acceptable peroxide value for fat and oils is up to 10 mill equivalents of active oxygen/kg. There was no countable PV detected in all the treatments during the storage period. Hence, fish

pastes produced in this study were free from the oxidative rancidity for the period of 60 days. Cooking process during canning prevents lipid oxidation and further interaction of oxidized lipids with protein like other constituents due to inactivation of endogenous enzymes (Naik *et al.*, 2014). According to the Naik *et al.* (2014), adding brine solution also increased the peroxide value during storage contrasting the results obtained in this study. This difference might be due to addition of spices such as Curry leaves (*Murraya koenigii*) (Jain *et al.*, 2012), Cumin seed (*Cuminum cyminum*) (Rebey *et al.*, 2012) and Black pepper (*Piper nigrum*) which have antioxidant properties that lead to scavenging of free radicals (Gülçin, 2005).

#### ***Microbial analysis (Detection of Clostridium botulinum)***

*Clostridium botulinum* is an anaerobic, heat resistant, spore-forming bacterium responsible for producing botulinum toxins under low-oxygen conditions (Brown, 2000). According to the USDA (2013), the canned product should be free from *C. botulinum*. According to the results, all the tested recipes were negative for *Clostridium botulinum* during 60 days of storage period claiming that these fish pastes are safe for human consumption for the 60 days of storage period.

**Table 02:** Changes of free fatty acid values (FFA) of the fish paste during 60 days of storage time.

Recipe	Day 1	Day 60
Recipe 01	2.80± 0.56 <sup>ba</sup>	3.76±0.33 <sup>ba</sup>
Recipe 02	3.93 ±0.53 <sup>aA</sup>	4.88± 0.32 <sup>aA</sup>
Recipe 03	2.63± 0.33 <sup>bb</sup>	3.57± 0.33 <sup>ba</sup>

Mean FFA values of the particular recipes are given in the table. Different letters in the same column show the treatment effect whereas letters in the same row shows the effect of storage period.

## CONCLUSION

Chub Mackerel (*Scomber japonicus*) tail offcuts during this study had the highest overall can be effectively utilized as a raw material to acceptability in terms of sensory attributes, produce a fish paste. Further, recipe 03 developed nutritional value and shelf life.

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