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Quality Improvement of Tilapia Fish Nuggets by Addition of Legume Flour as Extenders

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ABSTRACT

Fish mince based convenient products have become much popular among consumers. Therefore, incorporating fish mince with non-meat protein becomes an important production approach for reducing the cost and improving the nutritional, physical and sensory properties of the product. Hence the present study was focused on producing a Tilapia fish nugget with different legume flour i.e. lentil, chickpea and cowpea as an extender and masking the unpleasant sensory attributes of Tilapia fish due to its muddy flavor. Fish nuggets were prepared by using different composition of Tilapia fish mince (85, 75, 70, 65%), legume flour extender (0, 10, 15, 20%) and spice mixture (15%). Fish nuggets that were prepared by replacing 15% of Tilapia fish mince with legume flour were selected as the best out of all types of extenders. Accordingly, the prepared fish nuggets were kept in frozen storage (-18°C) and evaluated for proximate composition, cooking yield, shrinkage percentage, moisture retention, water holding capacity, pH, total plate count, free fatty acid value, peroxide value and total volatile based nitrogen for 3 months period. Results showed that the incorporation of legume flour significantly increased the protein content (20.28%) of nuggets compared to the control sample without legume flour (14.72%). Cowpea flour added fish nuggets revealed the highest cooking yield (78.89%), high moisture retention ability (34.15%), low diameter shrinkage (6.42%), good textural properties and same quality was observed even after 3 months of storage at -18ºC without addition of preservatives. Legume flour extenders enhance fish-plant protein matrix, thereby upgrading the product quality of Tilapia fish nuggets while improving the nutritional value. Further, among tested legume flour and cowpea flour ensured the best cooking, physical and keeping qualities as an extender for Tilapia fish nuggets than lentil and chickpea flour.

Keywords: Chickpea, Cowpea, Extenders, Fish-plant protein matrix, Lentil, Tilapia, Fish nuggets

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INTRODUCTION

Fish and fishery products contain high quality easily- digestible proteins, health beneficial polyunsaturated fatty acids and other necessary nutrients such as vitamins and minerals that are needed for human nutrition (Borderı´as *et al.,* 2005; Sánchez-Alonso *et al.,* 2007). According to Bollinger (2000), insoluble fiber has physiological advantages such as assistance on the chewing mechanism, stimulation of intestine function and influence on intestine transit period. Fish muscle does not contain dietary fiber (Borderı´as *et al.,* 2005). In preparation of fish mince based products, consideration of technological functionalities such as water holding capacity, fat binding capacity, viscosity, gelling properties, texturizing, etc., are required and, in this regard, dietary fiber plays a major role (Nelson, 2001;Sa´nchez-Alonso, 2007). According to the Koh *et al.,* (2011), the consumption quality of processed fish products can be improved by including the right amount and type of soluble-fiber polysaccharides in the formulation thus taking advantage of their multifaceted functionality as instrumental/sensory texture modifiers. Hence, to improve functional properties of fish based mince products, addition of suitable fiber source is desired.

Nile Tilapia (*Oreochromis niloticus*) is one of the most popular inland fish species in the world (Tokur *et al.*, 2004). Tilapia protein has a complete amino acid profile which consists of all essential amino acids recommended by the FAO of the United Nations and World Health Organization for of 2 to 5 year old children (Kirschnik *et al.*, 2007). Other than a good source of protein, Tilapia is alsorichin micro nutrients such as phosphorus, potassium, selenium, niacin and vitamin B-12 (Mjoun *et al.*, 2010).

Due to fast growth and easy adaption to the environment, Tilapia has become a widely cultured fresh water fish in Sri Lanka (Jayantha and Silva, 2010). In harvesting seasons, a large amount of Tilapia fish is produced. However, fishermen face with difficulties in marketing of this product due to limited facilities to access ice, quick transport and the short distribution channel. Therefore, most of the productions are wasted and access to this valuable protein source is lost to many Sri Lankans. Sri Lankan community prefers to purchase fishery products rather than meat products as there are less religious barriers. Urban population desire to acquire nutritious, convenient and palatable products for their meal, which suits to their busy lifestyle. Therefore, development of a fish mince based diversified, value added, and convenient fishery product to the local consumers is needed.

Tilapia fish is more suitable for fish mince-based products (Gopakumar, 1997) and the physical properties of Tilapia flesh are comparable to that of marine species (Hassan and Mathew, 1999).Thus, it is an ideal raw material for the preparation of value-added products including cooked products such as sausages and bologna, mince based fish nuggets, such as balls, fingers, burgers, etc., (De Oliveira *et al.*, 2012; De Oliveira *et al.*, 2010; Ninan *et al.*, 2010).

Plant and animal proteins are used in meat products to perform three basic functions: fat emulsification, water retention, and formation of structure of fish and meat products (Dzudie *et al.*, 2002; Mahendrakar *et al.*, 2003; Kenawi *et al.*, 2009). In developing a mince-based product, extenders or binders play a major role in forming a protein structural matrix (Gopakumar, 1997). Proteins from legume seeds have been widely studied with regard to functional and bioactive properties and also as one of the sources of plant proteins that can be used as an attractive alternative to wheat flour as a binder for replacement of a portion of the proteins in mince-based products (Shand *et al.*, 2011). Legume protein has been investigated as agoodsubstitute for gluten protein contained in wheat flour because of its functional properties such as highest water holding capacity, gelling properties and foam expansion capacity (Shand *et al.*, 2007). Moreover, the use of plant proteins in food as functional ingredients is considered to improve the stability, texture, nutritional quality of the product and as an important strategy to reduce overall production costs (Gramatina *et al.*, 2012; Osman *et al.*, 2012). Many researchers have been using non-animal proteins from variety of legumes like black eye bean, chickpea, lentil, soya bean, bengal gram, green gram, black gram and cereals like wheat as binders and extenders in mince based products (Mahendrakar *et al.*, 2003; Serdaroglu *et al.*, 2004; Sa´nchez-Alonso, 2007; Gramatina *et al.*, 2012). Considering these facts, present study was aimed to investigate the effect of lentil, chickpea and cowpea flour on improvement of technical functionalities, cooking properties, nutritional qualities and shelf life quality of Tilapia mince based nuggets.

MATERIALS AND METHODS

Tilapia fish purchased from local fish market (Pannala, North Western Province, Sri Lanka) were used in preparation of fish mince. Spices produced by Wijaya Products (Pvt) Ltd, Dodangoda, Kalutara, Sri Lanka were used. Lentil, chickpea and cowpea seeds were purchased from local market, Pannala, Sri Lanka. All chemicals used for the analysis were purchased from Sigma Aldrich Chemical Company, United Kingdom.

Preparation of Legume Flour

Lentil (*Lens esculenta* without seed coat, chickpea (*Cicerarietinum*) and cowpea (*Vignaunguiculata)* seeds with seed coat were used for the flour preparation. Chickpea and cowpea were soaked for eight hours while lentil was soaked for one hour. Soaked seeds were oven dried at 50ºC for 24 hours. Seeds were ground in a hammer mill [C.S.Bell's 20 (9") USA] to get flour in particle size of 0.45 mm.

Preparation of Fish Nuggets without Legume Flours

Head off, gutted, washed (cold water), skinned Tilapia were filleted. Tilapia fillets were minced using a laboratory meat mincer (General Food Service Meat Grinder Model: GSM50 U.S.A). Control sample of Tilapia fish nuggets were prepared for the purpose of comparison using 85% Tilapia fish mince, spice mixture (3.95% garlic paste, 1.02% pepper powder, 0.05% cardamom; the best spice combination was X_3 formula out of tested X_1- X_3 formulas, Figure 1), 1% salt, 2% egg white, 2% chilled water, 0.5% lime juice, 2.5% bread crumb and 2% wheat flour as binder. All ingredients were homogenized and the resulted mixture was shaped into round nuggets. Uniform coating of breading material prepared from finely ground plain taste crackers was coated on the surface after dipping the nuggets in egg white. Altogether, final weight of a fish nugget was approximately 10 g.

Extending Nuggets with Legume Flour

According to the procedure explained above, nuggets were extended with lentil, chickpea and cowpea flour as 10%, 15% and 20% for each legume to determine the best legume percentage for Tilapia fish nuggets. Control sample was prepared as described before without addition of legume flour. Simple ranking test method was used to select the best formula. Untrained fifteen member sensory panel was participated for the test. The results of simple ranking tests were analyzed by Kruskal-Wallis Test in MINITAB 15 software. Concurring to the test results, nuggets with 15% legume flour was selected to extend the Tilapia nuggets and carry out the shelf life analysis. Experimental samples were prepared as follows. The binder 2% of wheat flour and 13% of fish mince were replaced by addition of 15% of legume flour. Accordingly fish nuggets were prepared with 71.98% fish mince, 15% legume (lentil or chickpea or cowpea) flour, spice mixture (3.95% garlic paste, 1.02% pepper powder 0.05% cardamom, X_3 formula), 1% salt, 2% egg white, 2% chilled water, 0.5% lime juice, and 2.5% bread crumb (Figure 3).Freshly prepared fish nuggets were frozen at -18ºC for 2 hours until set, vacuum packed in Nylon-LLDP and further stored in -18ºC. Biochemical, physical, cooking and sensory qualities of the Tilapia fish nuggets were evaluated at two weeks intervals for a period of 3 months for chemical, physical, microbiological and sensory properties.

Chemical, Physical, Microbiological and Sensory Property Analysis of Tilapia Nuggets

Nuggets were analyzed for moisture and ash content by the method described by Oladipo and Bankole, (2013). Protein, fat and energy values were estimated according to AOAC (2000). Total volatile-based nitrogen (TVBN) content was estimated according to the micro diffusion method reported by Conway (1962). The peroxide value was determined according to Lea (1952) and the free fatty acid (FFA) value was determined by the method of AOAC (2000).The pH was measured in a slurry prepared by blending nugget and distilled water with 1:2 ratio.

Water holding capacity (WHC) was measured according to the method explained by Verbeken *et al.*, (2005) with slight modifications. Briefly, 1g nugget samples were dissolved in 10ml of distilled water in pre-weighted centrifuge tubes and they were mixed using a vortex for 5 minutes. Next, tubes were centrifuged at 5000 rpm for 30 minutes and the water layer was removed by placing tubes in an invert position (decanted). Then, the weights (wt) of centrifuge tubes were measured and WHC was calculated as follows.

% WHC = [(Tube wt after decanting–dry tube wt) –total nugget wt] (g) x100/ total nugget wt (g)

Cooking yield was determined as described by Murphy *et al.,* (1975). Nuggets were cooked in coconut oil pan for 2.5 min each side. Cooking yield was determined by calculating weight differences in samples before and after cooking according to the following equation.

Cooking Yield %= (Cooked nugget weight / Uncooked nugget weight) x 100

The moisture retention value represents the amount of moisture retained in the cooked product per 100 g of sample and was determined according to an equation reported by Osmanand Sukru (2012).

Moisture retention % = (%yield x %moisture in cooked nuggets)/100

The reduction in diameter of nuggets was determined with the following equation as percentage shrinkage in diameter (Osman and Sukru 2012) of cooked nugget (CN) and diameter of uncooked nugget (UCN).

Shrinkage in diameter %= (Diameter of UCN– Diameter of CN / Diameter of UCN) x100

Method described by Oladipo and Bankole (2013) was adopted to check the microbiological acceptance of nuggets kept in frozen storage. Samples were analyzed for microbiological parameters in three weeks interval.

Nine-point hedonic scale was used to evaluate color, flavor, texture, odor and overall acceptability of the cooked nuggets. Data were subjected to analysis of variance (ANOVA) using Minitab 15 statistical software using the criterion for significance at $p < 0.05$.

RESULTS AND DISCUSSION

Proximate Composition

The moisture, fat and ash contents in the formulations of different legumes; lentil, chickpea and cowpea extenders and control sample (without adding legume flour but adding 2% wheat flour) were not significantly different ($p>0.05$) from each other (Table 1). Incorporation of legume

Table 1: Proximate composition of uncooked Tilapia fish nuggets and water holding capacity of fresh nugget

Treatment	Moisture %	Protein %	Fat %	Ash %	Energy (cal/g)	Water holding capacity
Lentil	63.62±0.53	20.28^{a}±0.42	5.72±1.24	1.63±0.03	4586^{a}±55.4	65.10^{a}
Chickpea	64.43±0.66	18.32^{a}±0.68	5.34±0.10	1.69±0.04	4350^{b}±45.8	63.90^{a}
Cowpea	64.39±0.15	18.84^{a}±0.74	6.13±0.34	1.65±0.05	4231^{b}±27.3	63.15^{a}
Control	65.27±0.08	14.72^{b}±0.03	4.21±0.86	1.64±0.08	3902^{b}±46.3	57.18^{b}

Results produced as mean ±standard deviation, Different superscripts (a-b) in the same column indicate significant differences ($p < 0.05$).

flours increased protein percentage and energy value of the nuggets significantly ($p<0.05$) compared to the control sample, which did not include legume flour.

The highest protein content (20.28%) was observed in nuggets with lentil flour while cowpea and chickpea flour added nuggets had protein content of 18.84% and 18.32% respectively. Legumes contain relatively low amount of fat, therefore, the amount of fat in uncooked nuggets were not significantly different ($p<0.05$) in four formulations. Legumes provide energy, proteins, minerals, vitamins and most importantly dietary fibre required for human health. Most legume extenders enhance protein content, improve processing yields and reduce formulation cost as reported by Serdaroglu *et al.* (2005).

Cooking Properties

Table 2 shows the effect of legume flour extenders on the cooking properties of Tilapia fish nuggets. All samples experienced a reduction of diameter of nuggets after frying. Lentil, chickpea and cowpea flour added samples showed 8.01%, 8.41% and 6.42% shrinkage in diameter percentages respectively while control sample showed 12.83%, the highest diameter reduction value. The reduction was significantly higher ($p<0.05$) in the control sample, but legume flour containing samples had comparatively lower shrinkage in diameter percentage. Similar observation on reducing of shrinkage during cooking process by addition of legume protein as an extender has been reported by Kenawi *et al.*, (2009) and Teye and Boamah (2012).

Mincing destroys the structural integrity of the cell proteins and causes reduction in their water holding ability. This tends to shrink nuggets during the cooking process due to further denaturation of the myofibril proteins. Loss of water and fat in the cooking process also contribute to the shrinkage of nuggets. However, less diameter reduction may be caused by the formation of a hard crust on the product during cooking due to the higher extent of proteins in legume flour. Further, the use of fillers/extenders in meat/fish products improves the water retention capacity and minimizes the level of shrinkage resulting a higher yield, which impacts positively on the final product. Legumes consist of globulin represent roughly 70 % of legume seed proteins and consist primarily of the 7S, 11S and 15S proteins (Shand *et al.*, 2007).

Table 2: Cooking properties of nuggets prepared using different legume flour extenders

Treatment	Cooking yield %	Moisture retention %	Shrinkage diameter %	Cooking loss %
Lentil	74.14^{a}±0.54	31.90^{a}±0.50	8.01^{a}±0.13	25.70^{a}±0.74
Chickpea	77.27^{b}±0.43	31.34^{a}±0.43	8.41^{a}±0.30	22.73^{b}±0.43
Cowpea	78.90^{c}±0.51	34.15^{b}±0.74	6.42^{b}±0.50	21.07^{c}±0.56
Control	64.15^{d}±0.93	25.35^{c}±0.58	12.83^{c}±0.27	35.85^{d}±0.94

Results produced as mean ±standard deviation. Different superscripts (a–d) in the same column indicate significant differences (p < 0.05).

Molecular weights of these proteins range from 8000 to 600000 Da and these facilitate cross-linking between corpuscular strands thus building up a three-dimensional structure of globular proteins. Due to the formation of disulphide bridges upon thermal denaturation it reduces the shrinkage of the product. A significantly higher ($p<0.05$) value for cooking yield was recorded in legume flour added samples compared to the control. Among three legumes, cowpea flour containing nuggets had the highest (78.90%) cooking yield while control sample had the lowest (64.15%). When frying the product in oil, the crust of the nugget is dehydrated by the heat of the frying fat. The results of moisture retention in cooked nuggets showed that adding legume flour increases the moisture retention compared to the control sample. The highest value (34.15%) of moisture retention was observed in the sample added with cowpea flour while 31.90%, 31.34% and 25.35% were observed in lentil, chickpea and control samples respectively. Water binding and moisture retention were lower in the control sample when compared to nuggets added with legume flour (Table 1 and Table 2). Similar observations were made by Serdaroglu *et al*. (2005) in legume flour containing meatballs to sustain the highest moisture retention compared to the control samples. The lowest cooking loss value (21.07%) was obtained in samples containing cowpea flour whereas, the highest value (35.85%) was obtained in the control. The results revealed that the addition of legume flour as extender decreased the cooking loss in Tilapia nuggets. After considering all cooking properties of Tilapia nuggets, it can be suggested that nuggets with cowpea flour exhibited good textural properties in the final product compared to other three formulations.

pH of Nuggets

The change in pH of fish muscle is usually a good index for quality assessment. There was a continuous and rapid increase in the pH on the first week of frozen storage in control sample until 10thweek (Figure 2a). Other three formulations with legume flour had increased pH but not as rapid as in the control. This elevation in pH could be due to protein denaturation, formation of new cross linkages and reduction in acidic groups during cooking in the temperature range of 55-80°C as reported by Dushyanthan *et al.* (2008).

Table 3: Changes of sensory properties of nuggets

Storage time (weeks)		Lentil	Chickpea	Cowpea	Control
Color	0	7.00±0.85	7.13±1.13	7.00±1.07	6.60±1.45
	2	6.73±1.03	6.73±0.96	6.67±1.11	6.93±1.28
	4	6.73±1.49	6.13±1.36	6.06±1.33	6.87±1.19
	6	6.40±1.30	6.07±1.03	6.53±1.12	6.33±1.05
	8	5.20±0.77	5.40±1.18	5.47±1.12	5.10±1.33
Texture	0	6.13±1.41	6.13±1.41	6.47±1.60	6.10±1.50
	2	6.10±1.13	5.90±1.22	6.30±1.44	6.00±1.46
	4	6.33±1.59	5.60±0.99	5.90±1.28	5.80±1.52
	6	6.00±1.07	5.53±0.92	5.80±0.56	5.60±1.24
	8	5.10±0.80	5.00±1.20	5.20±1.39	5.07±1.22
Flavor	0	6.73^{ac}±1.33	6.60^{bc}±0.98	7.00^{a}±0.93	5.67^{bc}±1.54
	2	6.00^{abc}±1.07	6.53^{abc}±1.36	6.93^{ab}±1.33	5.33^{ac}±1.83
	4	6.33^{abc}±1.68	6.47^{abc}±0.99	6.87^{ab}±0.83	5.27^{ac}±1.57
	6	6.13^{ab}±1.30	5.20^{abc}±0.94	5.80^{abc}±1.42	4.73^{bc}±0.88
	8	5.26±1.39	5.33±1.91	5.47±1.55	4.47±1.59
Odor	0	6.73±1.22	6.60±1.30	6.67±1.23	6.33±1.91
	2	6.33±1.05	6.40±0.99	6.33±1.29	6.07±1.49
	4	6.27±1.58	6.26±1.22	6.20±0.86	5.20±1.42
	6	5.93±1.67	5.87±1.19	5.93±1.49	4.87±1.41
	8	5.40±1.40	5.60±1.50	5.80±1.42	4.47±0.92
Overall Acceptability	0	6.93^{a}±0.96	7.07^{a}±1.03	7.20^{a}±0.94	5.93^{b}±1.10
	2	6.67^{abc}±1.23	6.73^{abc}±0.96	6.87^{ab}±1.25	5.60^{ac}±1.35
	4	6.67^{a}±1.23	6.67^{a}±0.82	6.33^{ab}±0.82	5.33^{b}±1.34
	6	6.00^{ab}±1.13	6.13^{abc}±1.25	5.53^{ab}±0.91	4.80^{bc}±1.08
	8	5.13^{abc}±1.06	5.20^{ab}±1.01	5.60^{ab}±1.50	4.13^{ad}±0.99

Values with different letters in the row (a, b, c, d) for each parameter indicate significant differences ($p < 0.05$). Each value is a mean of 15 replicates.

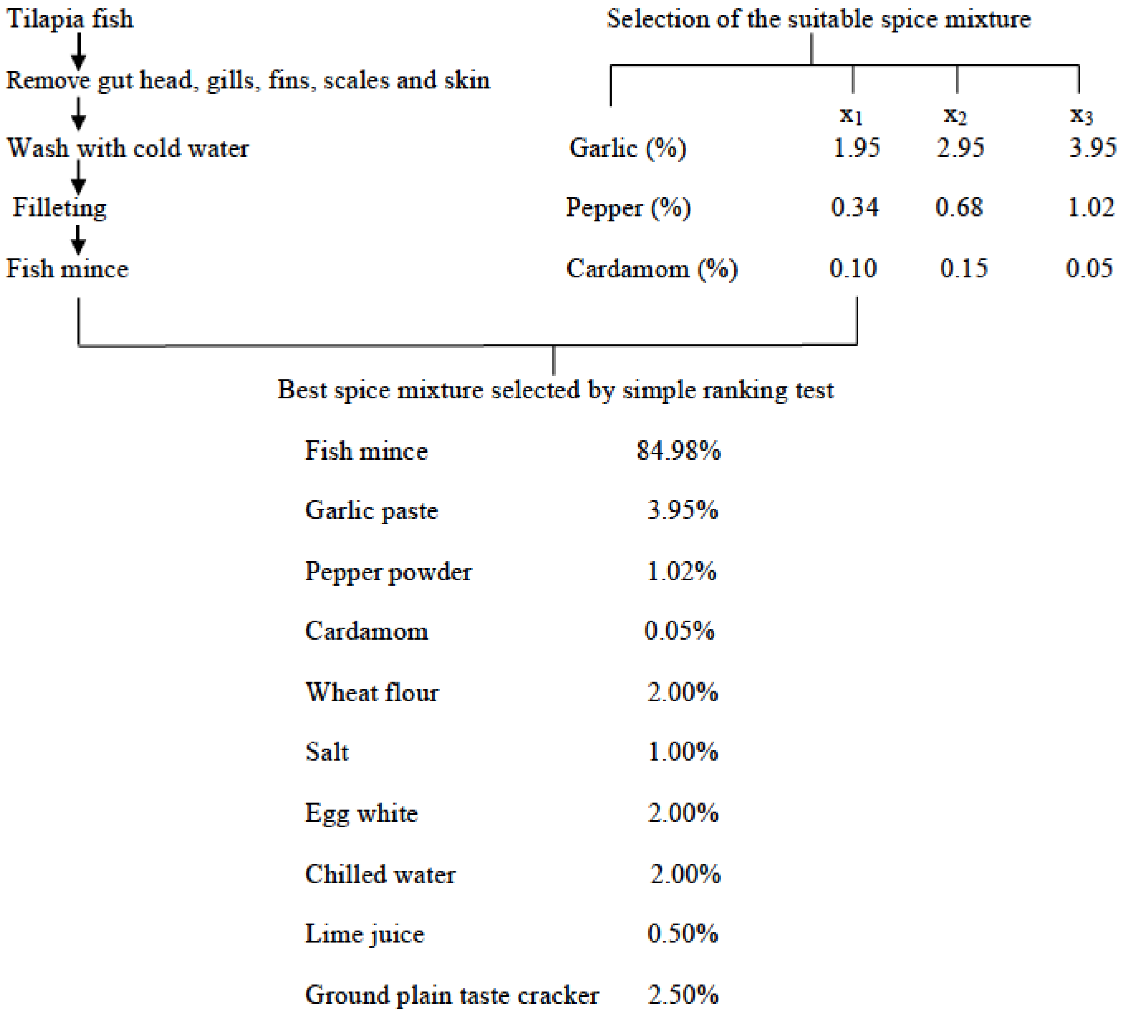

Figure 1: Flow chart for preparation of Tilapia fish nuggets for selection of the best spice combination

When considering chickpea and cowpea flour containing nuggets, their pH values had increased in more or less similar pattern compared to other lentil flour containing sample and control sample. Pawar *et al.* (2013) also showed that there was an increment in pH with time during frozen storage of fish cutlet.

Free Fatty Acid (FFA) Values

The accumulation of FFA during the processing or storage of food influences the quality of the final product and the period of shelf life. Presence of FFA mainly causes textural alterations by association with proteins. Accumulation of these lipids results in disagreeable flavors in food stuffs. Freshly prepared nuggets (before frying) had FFA contents in the range of 0.83 to 1.13% as oleic acid, which increased gradually from 6.37 to 8.28% during three months of storage (Figure 2b).

There was no definite trend of variation in FFA values shown between lentil and chickpea extenders. But the results showed that the least FFA values during storage were possessed by cowpea flour added nuggets. FFA value of control sample was high in every week compared to legume flour added samples. Increasing trend of FFA value during frozen storage conditions was similarly observed by Mahendrakar *et al.* (2003). The maximum acceptable level of FFA for fish products is 5% as oleic acid according to Bimbo (1998). The maximum acceptable level was achieved by the legume flour extended sample than control sample and it exhibited the stability of hydrolytic oxidation of the formulas may be due to their native antioxidant compounds.

Peroxide Value (PV)

Among the frozen products a significant increase in the peroxide value of the fish nuggets ($p< 0.05$) were observed during storage at -18^{o}C. For fresh fish nuggets the PV ranged from 1.33 to 1.80 meq O_2/kg of fat (Figure 2c). After 10 weeks of frozen storage, values were changed from 5.64 to 9.77 meq O_2/kg of fat. The peroxide test is a measurement of the formation of hydroperoxides. Hydro-peroxides are unstable and they break down into various compounds which produce off-flavours, leading to formation of a stale, rancid flavor in food products (Teye and Boamah, 2012). Therefore, an increase in the PV is most useful as an index of the earlier stages of oxidation. All the treatments exhibited an increasing trend in PV throughout the storage period. This might be induced by mechanical mincing of fish meat which accelerates oxidation due to incorporation of oxygen in tissues or the disruption and intermixing of tissue components. The nuggets with cowpea flour had the least increasing pattern in PV compared to other treatments. Teye and Boamah (2012) explained that in both beef and hamburgers, lipid per-oxidation was reduced with an increase in cowpea flour inclusion. He further noted that the use of cowpea flour therefore, has the potential of extending the shelf-life of the products.

Total Volatile Based Nitrogen (TVB-N)

The change in TVBN content of the products during frozen storage is given in Figure 2d. In the control sample of fish nuggets TVB-N reached up to 44.71 mg/100g from the initial 11.85 mg/100g within 10 week of storage. In fish nuggets with added legume flour, during frozen storage the change in TVB-N showed a similar pattern and it was within the range of 10.35 mg/100g to 34.64 mg/100g. Of all legume flour containing samples, the TVB-N value did not exceed the acceptable limit of 35 mg/100 g during frozen storage.

Microbiological Properties - Total Plate Count (TPC)

Changes in the total plate count (TPC) of the nuggets during frozen storage are shown in Figure 3. The TPC in fish nuggets decreased from 3.2×10^4 cfu/g of sample to 1.80×10^3 cfu/g of sample. The TPC decreased significantly from the third week in all types of fish nuggets ($p < 0.05$) during frozen storage. Reduction in the microbial load could be explained due to the freezing temperature and the powerful antimicrobial properties of food additives. Nearly 5 % of spice mixture could play a major role in antimicrobial properties. Vanitha *et al.* (2013) observed that freezing usually causes a reduction in bacterial count during storage for different fish products.

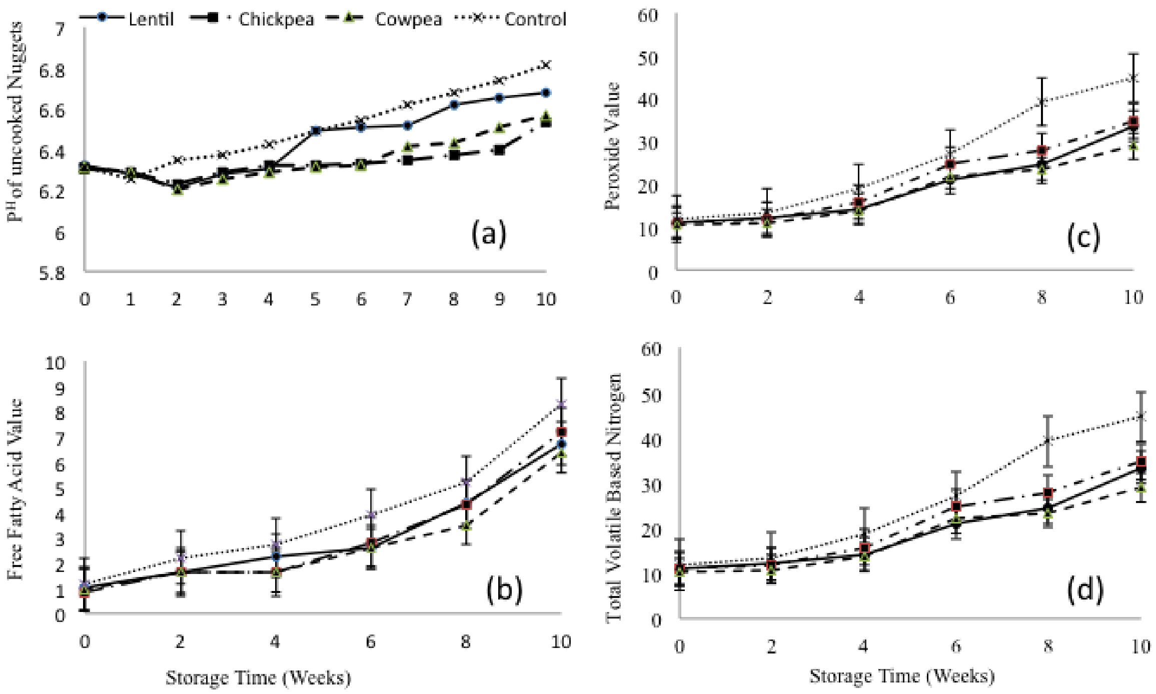

Figure 2: Changes of pH values (2a), Free fatty acid values (as % oleic acid) (2b), Peroxide value (meq/1kg of oil) (2c) and Total volatile based nitrogen (TVBN) values (2d) of nuggets stored at -18°C

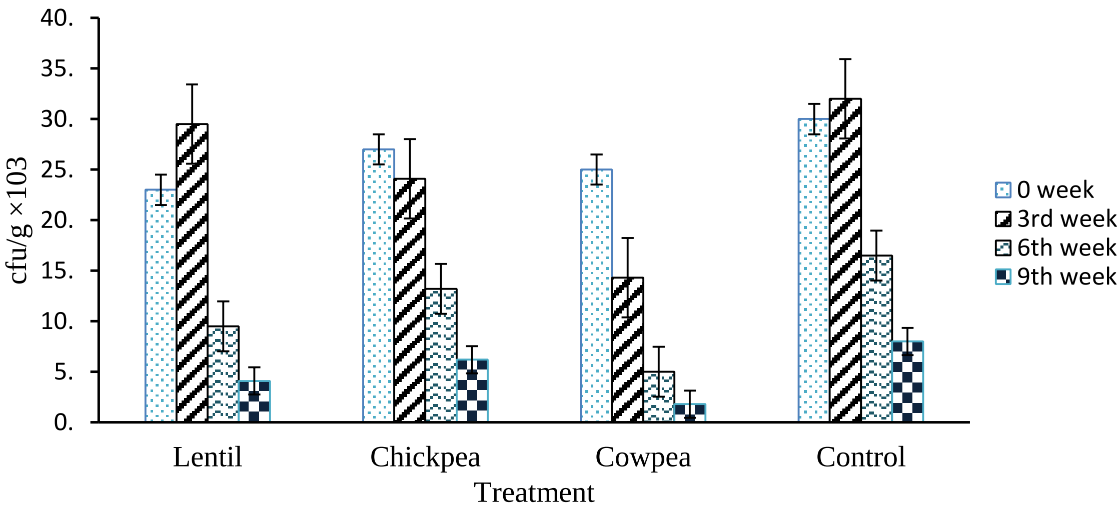

Figure 3: Total plate count of fish nuggets stored at -18°C

Sensory Properties

Table 3 shows the changes in sensory scores of nuggets during frozen storage up to 8 weeks. Fresh nuggets with cowpea flour received the highest initial score of 7.20 for overall acceptability whereas, lentil, chickpea and control received 6.93, 7.07 and 5.93 respectively. The results also showed that there were significant differences ($p<0.05$) in flavor and overall acceptability while other sensory properties did not have such differences. Addition of various ingredients including spices that have antioxidant properties might have protected the products from developing rancidity during the storage period. However, the product had acceptable flavor, odor and overall sensory qualities with a sensory score of 5, which was on the borderline of acceptance up to 8 weeks of frozen storage.

CONCLUSION

Use of lentil, chickpea and cowpea grains which are widely available in Sri Lanka can be successfully applied as extenders with their flour in preparation of Tilapia mince based fish nuggets. Inclusion of legume flour intensifies the nutritional value by enhancing protein and fiber content of the Tilapia fish nuggets. In addition, it also raises the physical quality and keeping quality of the formulated nuggets by increasing the water holding capacity, and decreasing the cooking loss. Among the tested legume flour, nuggets containing cowpea flour have the best cooking, physical and keeping qualities than nuggets added with lentil and chickpea flour.

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