Nutritional, Textural and Sensory Attributes of Spiced Shrimp Fortified Biscuits

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Nutritional, Textural and Sensory Attributes of Spiced-Shrimp Fortified Biscuits

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Abstract

Biscuits are a popular snack option consumed and appreciated across the globe due to their sensory attributes, long shelf life, and convenience. These products have their niche and are available in an array of tastes and flavours. An attempt was made to develop nutrient-rich spiced-shrimp fortified biscuits and assess the effect of the spiced-shrimp mix (SSM) (15-20 %) on the nutritional, physical, and sensorial attributes. Incorporation of the SSM into biscuits enhanced the nutritional profile of the biscuits. Inclusion caused a significant increase in the protein and mineral content of the biscuits. The water activity values of SSM biscuits ranged from 0.37-0.40. The SSM biscuits were thinner and lighter in comparison to the control ones. Further, a decrease in lightness (L*) value and an increase in redness value (a*) were observed upon supplementation with SSM. SSM-supplemented biscuits were preferred by sensory panellists, in comparison to control ones. The overall likeability of the supplemented biscuits lay in the 'like moderately to like very much' range of the 9-point Hedonic rating scale. The inclusion aided in the development of biscuits that could bestow consumers with good nutrition along with a spicy-delectable flavour.

Keywords: Shrimp, biscuits, protein, sensory attributes, texture, spiced-shrimp mix

Introduction

Rapid urbanization along with higher disposable income has changed the dietary pattern of the working population. Foods syncing with 'healthy-snacking' and 'food-on-the-go' are required to deal with current exigencies arising due to the hectic lifestyle that has burdened today's population. The health-conscious consumers are looking for healthy and ready-to-eat convenience foods.

Shrimp is considered as one of the most popular seafood items consumed across the world. It is rich in lipids, proteins, minerals, and vitamins (Seethi et al., 2022) and thus a salubrious ingredient. In recent years, shrimp farming has led to increased production and the value addition of shrimp is expected to offer ample opportunity for the creation of new avenues to realize commercial benefits.

Among all bakery products, biscuits have their niche (Kumar et al., 2018) and are available in a wide range of formulations, tastes and flavours to satiate the consumers' palate. They are one of the most popular bakery products consumed by a large segment of the population and offer a vast scope for any nutritional functionalization. The global biscuit market valued at 110.7 billion USD in 2021 is expected to reach 151.7 billion USD by 2027 (Imark, 2022). The salubriousness of the biscuits has been enhanced by the addition of various ingredients linked to fish i.e., salmon hydrolysate (Singh et al., 2020), marine collagen peptide (Kumar et al., 2019), fish bones (Abdel-Moemin, 2015), fermented *Johnius* (Zynudheen et al., 2013), tuna bone calcium powder (Benjakul & Karnjanapratum, 2018), Chinese sturgeon fish fillet powder (Abraha et al., 2018a), fish fillet protein concentrate (Abraha et al., (2018b), trout flesh powder (Savlak, 2020), anchovy fish (Thalib et al., 2021) and milkfish bone flour (Muzaki et al., 2021).

Under the current scenario wherein healthy snacks are in demand, biscuits have become the preferred option to be incorporated with healthful ingredients

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because of the pleasant taste and convenience associated. Abraha et al. (2018a) stated that children are not the beneficiaries of a healthier diet consisting of fish and fish products unless these products are incorporated into children's favourite foods like biscuits. Since biscuits are popular among children (Abraha et al., 2018b), they could be the beneficiaries of biscuits having enhanced protein content. The protein content of biscuits is low and the development of biscuits with enhanced protein content could be of potential interest to biscuit manufacturers (Savlak, 2020). Amalgamating shrimp in biscuits is expected to accentuate the protein content and modify the flavour attributes. Until now, scientific information describing the supplementation of shrimp in biscuits is minimal. Keeping this in consideration, the present study was designed to develop shrimp-fortified biscuits and assess the changes occurring in biscuit attributes thereon.

Materials and Methods

The shrimp (*Fenneropenaeus indicus*) used during the study was purchased from the fish landing centre, Cochin. The quality ingredients required for the preparation of biscuits were purchased from the local market and the formulation is detailed in Table 1.

The shrimp brought from the landing centre in iced condition was beheaded and peeled and washed thoroughly in potable water. Pre-processed shrimps were then dried in a fluidized bed dryer at 50 °C for 12 hours (moisture content <5 %), pulverized and then packed. Ground shrimp was fried in sunflower oil along with spices (Table 2) for around 5-6 minutes, with continuous stirring. The fried spiced shrimp was vacuum packed until further study.

Table 1. The formulation used for biscuit preparation

Ingredients	Parts
Refined wheat flour	100
Spiced-shrimp mix	15-20 %
Sugar	10
Oil	20
Baking powder	0.5
Ammonium bicarbonate	0.75
Emulsifier	0.5
Yeast	1.0
Papain	0.02
Water	20

Table 2. Spices used in the preparation of SSM mix

Ingredients	Weight (g)
Yellow mustard	0.3
Cinnamon	4.0
Cumin	6.0
White pepper	0.35
Cardamom	0.2
Mace	0.3
Clove	0.15
Star anise	1.5
Garlic	7.4
Ginger	26
Coriander	6
Black pepper	3
Red chilli	10
Turmeric	0.7
Salt	5

All the ingredients were weighed as planned and then mixed thoroughly for ten minutes in a planetary mixer (5KSM7990, Kitchen aid, USA). The dough formed was wrapped in cling film and allowed to rest at room temperature for 2 hours. The dough was sheeted using stainless steel roller (PN, La Monferrina, Alfero, Italy) and then shaped using a circular die of 26 mm. The biscuits were then baked in an electrical oven at 180 ºC for 7 minutes. The biscuits were allowed to cool at ambient temperature, packed in metallized polyester pouches, and then stored until further analysis.

Proximate composition (moisture, fat, protein, ash, and carbohydrate) of biscuit samples were evaluated as described in AOAC (2000). Moisture content was determined gravimetrically by drying in a hot air oven at 105 °C. The nitrogen content was determined by the Kjeldahl procedure and the protein content was calculated using 6.25 as the conversion factor. Lipid content was determined gravimetrically after the extraction with petroleum ether (40-60 °C) in a Soxhlet extractor. The ash content was determined gravimetrically in a muffle furnace by incinerating the charred samples at 550 °C. The carbohydrate content was determined by the mass difference. The analyses were carried out in duplicates. The calorie content of the biscuits was calculated by using the Atwater formula.

The Hunter colour parameters (L*, a*, and b* values) of powdered biscuit samples were measured using a spectro-colourimeter (Colorflex EZ 45/0, Hunter Lab, USA) having illuminant D65 and a visual angle of 10 °.

The thickness and diameter of biscuits were measured using Vernier callipers (CD-63 CSX, Mitutoyo Corporation, Japan). The biscuits were individually weighed using an analytical weighing balance (ME204, Mettler Toledo, USA). The water activity of the samples was directly measured by employing a water activity meter (Aqualab, Decagon Devices, USA) at 25 °C. The breaking strength and deformation biscuit samples were determined by a 3-point snap test as per Kumar et al. (2019).

The sensory analysis of biscuit samples was carried out by a semi-trained panel of experts from the division, using the following sensory descriptors: colour and appearance, taste, aroma, texture, and overall acceptability. The data obtained were subjected to a one-way analysis of variance (ANOVA) using IBM-SPSS Statistics ver.20 (SPSS South-Asia, Bangalore, India). The mean values were compared using Tukey's comparison test to know the significant (α- 0.05) difference.

Results and Discussion

The proximate composition of control and spiced shrimp fortified crackers is depicted in Table 3.

The moisture content of the biscuit samples was 3.59 % to 4.24 %. The water activity of the biscuits ranged from 0.39 to 0.40 (Fig. 1). Biscuits are known to be low moisture foods and their moisture content varies from 1-5 %. Moisture content coupled with reduced water activity makes biscuits a shelf-stable food having minimal risk of microbial growth and spoilage. But it also makes it very hygroscopic in nature. Further, the presence of lipids, makes biscuits prone to hydrolytic and oxidative rancidity under normal conditions. Therefore, the packaging considerations need to be met strictly for the stability of biscuits. The lipid content of the biscuit samples varied from 15.57 % to 20.99 %. Increasing the spiced-shrimp mix level increased the lipid content in the biscuits. An increase was noticed in the protein content of the biscuits upon the addition of SSM. The protein content increased from 8.09 % (control sample) to 14.34 % (20 % supplementation) viz. 77 % increase in protein concentration of biscuits. Akin to this, ash content, which determines the mineral level in the food, also showed a concentration-dependent increase. The ash content doubled from 1.02 % (control sample) to 2.05 % (20 % supplementation). The increase in lipid content and protein content is also reflected in the calorific value of the biscuits as calculated by Atwaters' formula. The calorie content of the biscuit increased from 459 Kcal to 480 Kcal.

The dimensional parameters of the biscuits viz., thickness, diameter and weight (Table 4) play

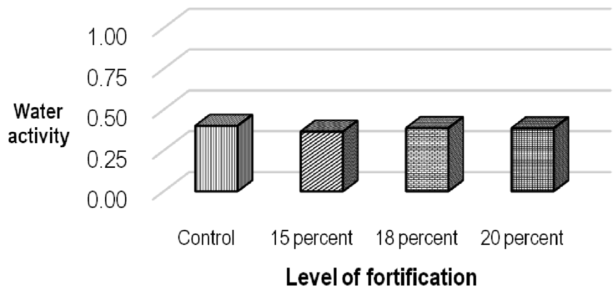

Fig. 1. Water activity values of biscuits prepared with SSM

Table 3. Proximate composition of SSM supplemented biscuits

Parameters	Control	SSM supplementation level		
		15 %	18 %	20 %
Moisture (%)	3.59±0.37^{a}	3.65±0.33^{a}	3.99±0.18^{a}	4.24±0.23^{a}
Fat (%)	15.57±1.80^{a}	19.30±0.88^{a}	20.35±.1.48^{a}	20.99±1.58^{a}
Protein (%)	8.09±0.83^{a}	10.60±0.69^{ab}	12.70±0.71^{bc}	14.34±0.79^{c}
Ash (%)	1.02±0.17^{a}	1.65±0.17^{b}	1.93±0.04^{b}	2.05±0.08^{b}
Carbohydrate (%)	71.7	63.8	61.0	58.4
Calorie (Kcal)	459	471	478	480

*Values between different columns are significantly (p<0.05) different

Table 4. Dimensional and colour values of SSM supplemented biscuits

Parameters	SSM supplementation level			
	Control	15 %	18 %	20 %
Thickness	7.10±0.54[a]	5.53±0.30[b]	5.34±0.21[b]	4.67±0.26[c]
Diameter	27.93±0.73[a]	27.86±0.58[a]	27.83±0.67[a]	27.84±0.39[a]
Weight	2.41±0.18[a]	2.17±0.09[b]	2.12±0.04[bc]	2.00±0.06[c]
L*	84.76±0.20[a]	66.90±0.04[b]	61.56±0.08[c]	61.77±0.14[c]
a*	0.92±0.02[a]	10.75±0.25[b]	11.55±0.11[b]	12.66±0.13[d]
b*	15.33±0.02[a]	32.64±0.55[b]	34.47±0.13[c]	34.67±0.25[c]

*Values between different columns are significantly ($p<0.05$) different

important role in controlling the texture of the biscuits. Further, the knowledge of these properties aids in package development (Kumar et al., 2018). The thickness and diameter of the biscuits ranged from 4.67 mm to 7.10 mm and 27.83 mm to 27.93 mm. The thickness of the biscuit decreased significantly ($p<0.05$) with the addition of the SSM mix while the difference in diameter was non-significant ($p>0.05$). The biscuits became thinner after the addition of SSM. Similar to these results, Gallagher et al. (2005) observed decrease in thickness of biscuits with increasing whey protein levels. Singh et al. (2020) also noticed a variation (6.30 - 10.12 mm) in the thickness of the biscuits upon supplementation with debittered salmon frame hydrolysate. This variation was also evident in the weight of the biscuits, which deviated from 5.33 - 6.96 g. The decrease in thickness could be attributed to the interaction of the SSM mix with flour protein, which altered the dough machinability.

Gluten development is known to give a better baking performance (Kweon et al., 2011a) and the thickness of the biscuits is controlled by the snap-back of the dough (Kweon et al., 2011b). It is expected that the addition of SSM interfered with the gluten development in the dough. Further, the height of control biscuits might have increased due to the leavening action of yeast. The incorporation of SSM might have interacted with the carbohydrates/sugars present in the dough and reduced its availability for the growth of yeast. Further, the addition might have caused weakening of the matrix for CO_2 trapping, thus reducing the thickness. The addition of defatted salmon hydrolysate in biscuits was found to dilute amylose and amylopectin and weakened the matrix for carbon dioxide trapping and consequently reduced the thickness of biscuits (Singh et al., 2020). The amylose and amylopectin trap the leavening agent (air and carbon dioxide) generated and raises the dough, which subsequently imparts puffiness to the baked product (Benjakul & Karnjanapratum 2018; Singh et al., 2019). Similarly, the addition of SSM also led to a significant ($p<0.05$) decrease in the weight of the biscuits, which is in line with the reduction in the thickness of the biscuits. The weight of the biscuit also depends upon the loss of water due to evaporation upon baking. The higher loss could be attributed to the lack of structural integrity, which allowed for easy evaporation during baking. Generally, a lower weight loss is preferred for shape retention and loss of components during baking. The texture along with dimensions and weight loss are linked to the microstructure of biscuit dough and biscuit (Rodriguez-Garcia et al., 2013).

The colour of biscuits was expressed in terms of Hunter colour values (L^*, a^*, b^*). L^* value signifying lightness decreased significantly ($p<0.05$) from 84.76 (control) to 61.77 (20 % supplemented) with the addition of SSM. Positive a^* value signifying the redness component of the colour, increased significantly ($p<0.05$) from 0.92 (control) to 12.66 (20 % supplementation) with SSM incorporation. A similar effect was also observed in the Hunter b* value, which increased with SSM fortification in biscuits. As evident from Fig. 2, the SSM imparted its colour attributes to the biscuits, which might have been modified due to Maillard browning (Mundt & Wedzicha, 2007) and caramelization (Lara et al., 2011) occurring in biscuits during the course of baking.

The textural properties of the biscuits were evaluated by 3-point bend test. It measures the force

Fig. 2. SSM supplemented biscuits

required to bend the sample and is commonly used for analyzing brittle foods (Sahin and Sumnu, 2006). Bending has been described as a combination of compression, tension and some shear. Bending tests can be easily performed and fixing the sample is not necessary. The fracture occurring on account of bending can be observed easily in the test. The biscuit sample is supported on two beams and the third moves down to break the biscuit. The deformation distance is the distance before the sample fractures the failure limit of the material. Snap is considered as a desirable attribute in crisp foods i.e. beans, potato chips, snack items etc. Snapping ability is related to the amount of shortening present in baked goods. The sharp sound emanating as a consequence of snapping is due to high energy sound waves generated, when the sample is fractured rapidly and broken parts return to their former configuration. The snapping

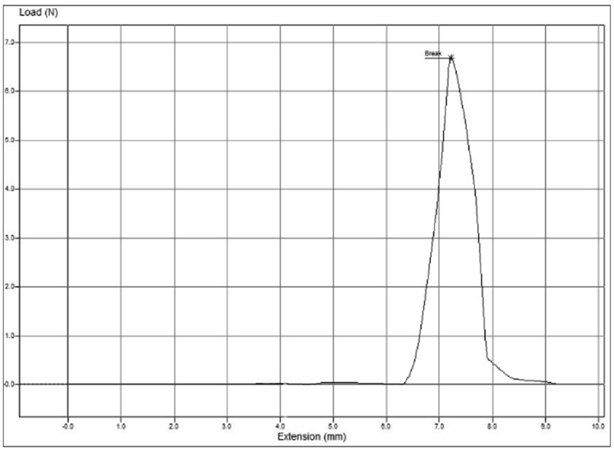

Fig. 3. Snap test for SSM incorporated biscuits

test indicates the fracturability/ brittleness/ crispness of the product (Stable Micro Systems, 2023). Fig. 3 depicts a typical 3-point bend test curve of the biscuit.

A significant difference was observed in the breaking strength and deformation characteristic of the SSM-supplemented biscuits. The deformation distance is the distance before the sample fractures- the failure limit of the material. A significant difference was observed in the breaking strength and deformation characteristic of the SSM-supplemented biscuits. The incorporation of SSM decreased the breaking strength and deformation significantly ($p<0.05$) (Table 5). Since the force required to snap is linked to the thickness and diameter of the sample, the decrease in breaking strength could be directly linked to the decrement noticed in the thickness and weight of the biscuits. As can be seen from the decline in deformation distance, the addition of SSM increased the brittleness of the biscuits.

Table 5. Breaking strength and deformation distance of SSM supplemented biscuits

Sample	Breaking strength (N)	Deformation (mm)
Control	10.90 ± 2.32^{a}	0.82 ± 0.12^{a}
15 %	5.07 ± 1.88^{b}	0.58 ± 0.06^{b}
18 %	4.75 ± 1.56^{b}	0.60 ± 0.05^{b}
20 %	3.21 ± 0.86^{b}	0.60 ± 0.04^{b}

*Values within columns with different superscripts are significantly ($p<0.05$) different

Even though consumers are oriented towards health foods, the consumption and end success of the food product depend upon the sensory quality of the food product (Stone, 2018). It is necessary for the continual success of the product in the market (Vivek et al., 2020) and a measure of the consumer's acceptance of the product. As indicated by the radar diagram (Fig. 4), the addition of SSM enhanced the colour and appearance score of the biscuits.

The reddish colour appealed more to the panellists than the normal light colour of the control samples. The taste and aroma scores were also enhanced due to SSM incorporation into biscuits. The SSM biscuits were tastier and liked by the panellists more in comparison to the control ones. The texture score of the biscuit samples ranged from 7.26 to 7.68 on a

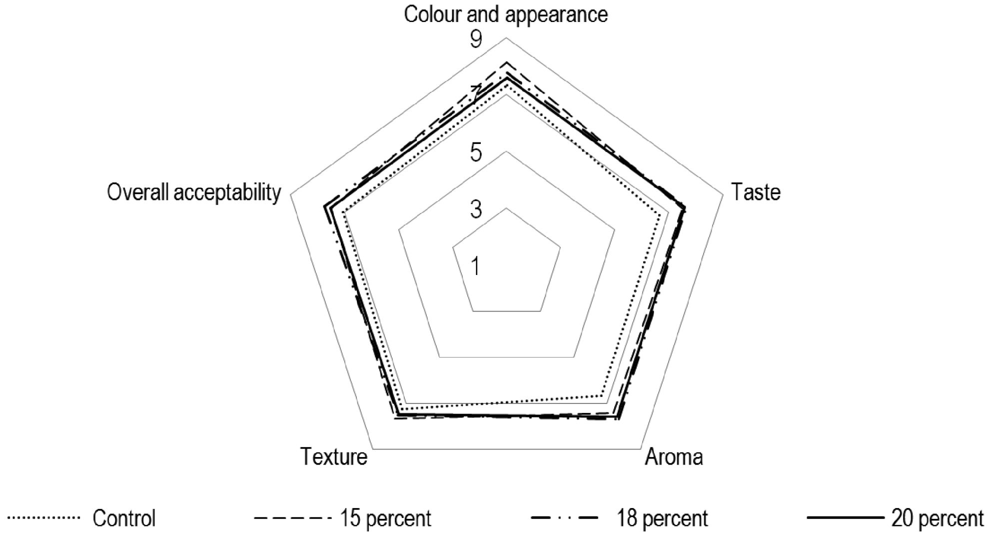

Fig. 4. Sensory behaviour of SSM supplemented biscuits

9-point Hedonic scale. The overall acceptability of biscuit samples was in liked moderately to liked very much range. In general, the addition of SSM (15-20 %) enhanced the sensory properties of the biscuits.

Hence, the incorporation of shrimp in the form of SSM mix appeared to be well justified since the addition led to increased energy, protein and mineral content of the biscuits. Addition further led to enhanced sensory appeal of the product. The biscuits have the potential to impart nutritional attributes of shrimp in a palatable manner in the human diet.

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