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Qualities of Octopus Meat Balls Developed Using Smashed Potato and Bengal Gram Starches

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Abstract: Cephalopods are having very good internal and export market. The cephalopods are having squids, cuttle fish and octopus. Among these squids and cuttle fish are very famous like crustaceans and are having very good export market. But the octopus is not famous like other seafood and fisher man never goes for octopus fishing. But during fishing they used get as a by catch and normally fisher folks dispose it in the shore itself. The octopus, *Octopus cyanea* is found commonly in Tuticorin waters and is often caught in fishing nets. The main objective of the present work is to utilize this underutilized cephalopod in a better way. Meat balls were developed by combining the octopus meat with two different starches such as Bengal gram flour and smashed potatoes. The developed meat balls were found to have characteristic flavor and attractive appearance for consumption. The meat balls were frozen stored for a period of 49 days and the biochemical, microbiological and organoleptic analysis were carried out once in every 7 days. Meat balls are having very good sensory qualities and taste.

Key words: Meat balls · *Octopus cyanea* · Starches · Biochemical analysis · Organoleptic

INTRODUCTION

Cephalopods, of the Phylum Mollusca have a special place in kitchens all over the world. Except for the *Nautilus* sp., other members such as squids, cuttlefishes and octopus are consumed worldwide. Most of the cephalopods are consumed fresh or cooked. Japanese eat cuttlefish meat and squid meat raw (sashimi) with sauce. They also prepare value added products such as meat balls (Takoyaki) from octopus meat. Seafood balls and fish balls are popular processed products commonly consumed with noodles in the South East Asian region. They go by different names such as Bebola in Malaysia, Brunei, *Bakso* in Indonesia, *Bola-bola* in Philipines, *Bakso* in Singapore and Luck-chin pla in Thailand [1]. In Malaysia meat balls with different starches are famous and the physicochemical properties of Malaysian fish balls were reported [2]. Fish balls are normally sold fresh or as chilled frozen items in super markets [3]. Several value added products from molluscs such as *Chicoreus ramosus* [4], *Babylonia spirata* [5], *Pleuroploca* trapezium [6] and *Sepioteuthis lessoniana* [7] have been developed in India. Preference of ready to cook or ready to serve products is on the increase [8].

Consumption of octopus is negligible In India, but export of the cephalopod has been ongoing for some time. There is, however, no targeted fishing of octopus in India and most of them are a by-catch or are accidentally trapped while trawling. Usually these accidentally trapped animals are thrown back into the sea or abandoned on the shore while cleaning the nets. Thus the octopus resource in India remains highly underutilized and in the present study, we have developed a value added product in the form of octopus meat balls from this untapped resource.

MATERIALS AND METHODS

Processing the Raw Cephalopod Meat: An Octopus weighing 1.15 kg was collected from the fishermen which was photographed (Fig. 1) and later identified as *Octopus cyanea* with the help of a cephalopod taxonomist.

The sample was immediately washed, deskinned and degutted. The mantle and arms which constituted the edible portion consisted 67.83% of the total body weight. Mantle weighed 60g and arms weighed 720g. The edible meat was washed thoroughly with potable water and cut into small pieces. The cleaned meat was cooked in water for 15 minutes for softening and removing the mucus.

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Fig. 1: *Octopus cyanea*

Table 1: Standard recipe for the preparation of the meat balls

Ingredients	Quantity
Minced octopus meat	500g
Bengal gram flour /cooked and minced potato	500g
Sesame seeds	16g
Big onions	5 nos
Curry powder	3.5g
Pepper powder	3.5g
Ascorbic acid	0.166g
Sodium benzoate	0.166g
Salt	12g

The water was drained off and the meat was cooled. The meat was further minced in a mixer grinder without adding any water.

Preparation of Meat Balls: The ingredients used in the meat ball preparation are given in table 1. The onions were cleaned and chopped into small fine pieces and were fried in edible oil until golden brown color and allowed to cool. Sesame seeds were roasted until bursting under low heat and removed from the pan and cooled. Two batches of meat balls were prepared. In the first batch the minced meat of octopus was mixed with Bengal gram flour, curry powder, pepper powder, fried onions and sesame seeds and then mixed thoroughly. In the second batch the minced meat was mixed with boiled, skinned and smashed potato with curry powder, pepper powder, fried onions and sesame seeds and then mixed thoroughly. Finally, ascorbic acid and sodium benzoate were added to each batch as preservatives and the mixture was seasoned to taste with salt and mixed thoroughly. The mixture was then formed into small balls of uniform size of about 2-3 cm by rolling sufficient amounts of the dough between palms (Fig 2a and 2b).

(a) (b)

Fig. 2a-b: (a) Octopus meat balls prepared using Bengal flour gram starch
(b) Octopus meat balls prepared using smashed potatoes

(a) (b)

Fig. 3a-b: (a) Fried octopus meat balls prepared using Bengal flour gram starch
(b) Fried octopus meat balls prepared using smashed potatoes

The meat balls were then wrapped in aluminium foil and packed in airtight plastic pouches. Packed meat balls were stored at -18°C in a freezer in order to investigate storage characteristics of the final product. For consumption, the meat balls were fried in refined oil till the surface turned uniform brown color (Fig. 3a and 3b).

Biochemical Composition of Meat Balls: The protein content was estimated by methods of Raymont [9]. Lipid and carbohydrate contents were estimated by standard methods [10, 11]. For protein analysis 0.2g dry weight of the sample was used and for the carbohydrate analysis 20g of the dried sample was used. Thaw and drip loss, moisture, pH, Free Fatty Acid (FFA) and Total Plate Count (TPC) were estimated during the 49 days storage period. Other spoilage indicators such as Tri Methyl Amine–Nitrogen (TMA-N) and Total Volatile Base–Nitrogen (TVB-N) also where observed once in 7 days during the storage period.

The thaw and drip loss was carried out by thawing the meat balls in polythene bags. The bags were kept under running tap water at room temperature for 1-2 hours and the drip formed in the bag was drained and the drip loss was measured. The differences in the weight of the meat ball prior to thawing and after thawing gave the thaw and drip loss values. Moisture content was determined by drying 5 g of meat ball in a pre weighed Petri plate kept in a mechanical drier for 2 days and weighing again. To measure the pH of the sample, 10g of the sample was homogenized with 50 ml of distilled water and the pH of the homogenate was measured using a digital pH meter. FFA content was measured by using titrimetric method [12]. The total volatile base-nitrogen and tri methyl amine-nitrogen (TMA-N) was estimated using Conway micro diffusion method [13].

Microbial Analysis: Total plate count was enumerated by the APHA method [14]. For TPC the sample was serially diluted for enumeration. Presence of pathogenic forms such as *Vibrio, Salmonella* and *Escherichia coli* were checked by the methods of USFDA [15].

Organoleptic Properties: Sensory evaluation of the fried meat balls were done by following the method of Amerine [16] and appearance, color, odor, taste, texture and flavour were judged. The overall acceptability was also determined using hedonic scale of 1 to 9 using the same methodology. The organoleptic scores of meat balls were rated as 9 for excellent, 6 for good and below 4 as unacceptable. This analysis was carried out weekly and the change in quality was noted.

Statistical Analysis: Significant differences in the spoilage indicators between the two different types of meat balls were analyzed using the One Way ANOVA test.

RESULTS

The percentage of protein, lipid and carbohydrate contents in the octopus meat and the two meat balls are given in table 2.

Tables 3 and 4 give the biochemical and microbiological quality of meat balls prepared from octopus meat using Bengal gram and smashed potatoes as starches respectively over the storage period of 49 days. One way ANOVA analysis showed a significant difference ($P<0.05$) in pH with increasing storage period in both types of meat balls. Free Fatty Acid (FFA-% oleic acid) content of meat balls prepared using Bengal gram starch increased from an initial value of 1.04 to 7.89 after the 49 days of storage in polythene bags. A similar gradual increase in FFA was also observed in meat balls prepared using smashed potato starch (from 1.49 to 5.62).

Tri Methyl Amine-Nitrogen (TMA-N) levels and Total Volatile Base-Nitrogen (TVB-N) were found to increase gradually with storage in both the types of meat balls. In the Bengal gram containing meat balls, TMA-N increased from 1.97 to 3.68 (mg/100g) and TVB-N increased from 2.57 to 6.21 (mg/100g). In the smashed potato starch meat balls, TMA-N increased from 2.19 to 4.62 and TVB-N increased from 2.78 to 6.69 (mg/100g).

Table 2: Biochemical composition of octopus meat and meat balls prepared Using Bengal gram flour starch and smashed potato starch

Biochemical parameters	Octopus meat	Meat balls using Bengal gram flour starch	Meat balls using smashed potato starch
Protein (%)	12.850	13.100	13.170
Lipid (%)	2.280	2.570	2.610
Carbohydrate (%)	1.426	1.964	3.452

Table 3: Biochemical and microbiological characteristics of octopus meat balls prepared using Bengal gram as starch

	Storage period								
Parameters	0	7	14	21	28	35	42	49	p-value
pH	7.24±0.01	7.06±0.02	6.92±0.01	6.81±0.01	6.78±0.01	6.62±0.02	6.54±0.01	6.31±0.01	0.0114*
FFA (% of oleic acid)	1.04±0.02	1.22±0.01	2.17±0.01	3.21±0.01	4.51±0.01	5.37±0.01	6.74±0.02	7.89±0.01	0.004**
TMA-N (mg/100g)	1.97±0.02	2.43±0.01	2.92±0.03	3.03±0.02	3.22±0.03	3.56±0.03	3.61±0.01	3.68±0.01	0.003**
TVB-N (mg/100g)	2.57±0.02	3.42±0.03	4.55±0.02	5.62±0.01	5.77±0.02	5.97±0.01	6.05±0.01	6.21±0.02	0.006**
Moisture (%)	45.37±0.5	46.8±0.2	48.37±0.02	48.49±0.02	49.2±0.01	49.38±0.02	49.39±0.01	49.6±0.03	0.001**
TPC (x102 CFU/g)	25.7±2.1	35±2.6	49±1	54±2	72.3±2.5	83.7±3.2	92.7±2.5	108.3±2.1	0.004**
Thaw drip loss (%)	0.028±0.03	0.04±0.02	0.045±0.01	0.059±0.04	0.08±0.04	0.17±0.03	0.28±0.04	0.35±0.02	0.001**

Mean±SD; n=3; * - P<0.05; ** - P<0.01

Table 4: Biochemical and microbiological characteristics of octopus meat balls prepared using smashed potato starch

	Storage period								
Parameters	0	7	14	21	28	35	42	49	p-value
pH	7.42±0.04	7.26±0.05	7.1±0.02	7.27±0.06	6.93±0.06	6.82±0.04	6.78±0.02	6.67±0.07	0.012*
FFA (% of oleic acid)	1.49±0.04	2.53±0.04	2.75±0.02	2.99±0.04	3.35±0.02	3.56±0.02	4.38 ±0.04	5.62±0.04	0.0036**
TMA-N (mg/100g)	2.19±0.03	2.63±0.03	3.24±0.03	3.35± 0.04	4±0.02	4.04±0.02	4.37±0.02	4.62± 0.04	0.0039**
TVB-N (mg/100g)	2.78±0.02	3.65±0.05	4.51±0.03	5.74±0.03	5.96±0.04	6.24±0.04	6.45±0.03	6.69±0.01	0.006**
Moisture (%)	46.8±0.08	48.2±0.06	49.4±0.04	49.9±0.08	50.2±0.05	50.7±0.09	50.9±0.09	51.4±0.06	0.001**
TPC (x102 CFU/g)	32.3±3.5	41.7±3.1	49.3±1.5	54.7±1.5	70.7±2.1	83.7±4	93.3±2.5	110±5	0.002**
Thaw drip loss (%)	0.058±0.01	0.064±0.01	0.076±0.01	0.092±0.02	0.16±0.01	0.17±0.016	0.28±0.02	0.61±0.03	0.001**

Mean±SD; n=3; * - P<0.05; ** - P<0.01

Table 5: Organoleptic characters of the octopus meatballs prepared using Bengal gram starch

	Storage period								
Parameters	0	7	14	21	28	35	42	49	p-value
Appearance	8.3±0.7	8±0.5	8±0.5	7.8±0.6	7.7±0.3	7.5±0.3	7.4±0.4	7.2±0.2	0.0151*
Colour	8.1±0.5	7.8±0.7	7.6±0.5	7.5±0.5	7.5±0.4	7.4±0.4	7.2±0.2	7.2±0.3	0.0142*
Odour	8.2±0.6	8±0.5	7.8±0.6	7.7±0.4	7.6±0.5	7.5±0.5	7.4±0.3	7.2±0.4	0.0148*
Taste	8.3±0.6	8±0.3	7.6±0.5	7.6±0.6	7.6±0.4	7.6±0.4	7.6±0.3	7.5±0.1	0.0151*
Texture	8.5±0.4	8.2±0.4	7.5±0.7	7.5±0.5	7.4±0.3	7.2±0.3	7±0.5	6.9±0.2	0.0142*
Flavour	8±0.5	8.2±0.4	7.5±0.4	7.5±0.5	7.4±0.3	7.2±0.2	7±0.1	6.9±0.1	0.0139*
Overall acceptability	8.3±0.6	8±0.4	7.6±0.5	7.5±0.1	7.4±0.2	7.2±0.3	7±0.3	6.9±0.2	0.0140*

Mean±SD; n=3; * - P<0.05

Table 6: Organoleptic characters of the octopus meat balls prepared using smashed potato starch

	Storage period								
Parameters	0	7	14	21	28	35	42	49	p-value
Appearance	8.5±0.5	8.5±0.6	8.2±0.4	7.8±0.2	7.9±0.09	7.8±0.1	7.7±0.2	7.5±0.07	0.016*
Colour	8.3±0.7	8.4±0.5	8.5±0.5	8±0.6	7.8±0.3	7.5±0.2	7.2±0.4	7±0.09	0.015*
Odour	8.5±0.5	8.2±0.7	8±0.5	7.7±0.3	7.6±0.4	7.6±0.5	7.4±0.09	7.2±0.3	0.0154*
Taste	8.7±0.6	8.5±0.5	8.2±0.4	8±0.08	7.8±0.6	7.7± 0.4	7.5±0.4	7.5±0.3	0.0163*
Texture	8.5±0.7	8.5±0.7	8.2±0.5	8±0.8	7.8±0.4	7.6±0.4	7.6±0.3	7.6±0.05	0.0164*
Flavour	8.5±0.5	8.2±0.7	8± 0.6	7.8±0.4	7.7±0.5	7.5±0.4	7.5±0.3	7.5±0.09	0.0157*
Overall acceptability	8.5±0.4	8.5±0.5	8.2±0.2	7.8±0.5	7.6±0.4	7.6±0.5	7.5±0.2	7.5±0.3	0.0160*

Mean±SD; n=3; * - P<0.05

The initial moisture content in the meat balls prepared using Bengal gram was 45.37 and it increased to 49.6 by the end of the storage period of 49 days. There was a similar increase in the meat balls prepared with smashed potatoes where the initial moisture was 46.8 which increased to 51.4 at the end of the storage period. The total plate count also increased from an initial 25.7 x 10^2 to 108.3 x 10^2 in meat balls with Bengal gram starch and 32.3 x 10^2 to 110 x 10^2 in meat balls with smashed potatoes. Pathogenic bacteria such as *E. coli*, *Salmonella* and *Vibrio* were not encountered in both the products throughout the storage period.

One way ANOVA analysis showed that the differences with storage observed in FFA, TMA-N, TVB-N, moisture, TPC and thaw and drip loss parameters were highly significant (P<0.01).

Results of the organoleptic characteristics of the meat balls prepared using Bengal gram and smashed potato starches are given in tables 5 and 6. The mean scores for all organoleptic characteristics remained within acceptable limits throughout the storage period, although the sensory scores showed a decreasing trend. One way ANOVA test showed that the difference in organoleptic parameters were significant (P<0.05).

DISCUSSION

The protein, lipid and carbohydrate contents increased in the meat balls than the raw meat. Furthermore, the protein values of octopus meat balls were higher than the gastropod, *Pleuroploca trapezium* meat balls [16]. These findings suggest that the nutritious quality of the meats were improved by the additives. During the period of storage, pH gradually decreased in both types of meat balls. pH of meats has been reported to be one of the most important parameters in determining drip loss in thawed meat [17, 18]. Free Fatty Acids were observed to increase progressively through the storage days. Oxidation hydrolysis of lipids in the meat during the storage could cause deterioration in the quality of the meat and this could result in the formation of FFA [19]. The addition of ascorbic acid reduces the Free Fatty Acid (% of Oleic acid) production due to its antioxidative properties. TMA-N and TVB-N also showed an increasing trend during the study period. Generally TMA-N is often used as an index to assess the quality and shelf life of seafood products [20]. Though the TMA-N levels showed an increasing trend, the values were well within the acceptable limits of 15mg/100g [21]. The initial TMA-N values could be due to the low microbial load in the sample and it could be correlated with the total plate count [22]. TVB-N is an indicator of low molecular weight volatile bases and amine compounds produced by microbial oxidation of amino acids [23, 24] along with TMA-N and other metabolites which result from the bacterial or enzymatic breakdown of tissue. In the present study the increase in TVB-N content of meat balls with storage was similar to that of TMA-N and the levels were within the acceptable limits of 30 mg/100 g acids [25]. The values of TMA-N and TVB-N were found well within the acceptable limits of 30 mg 100 g^{-1} [26] at the end of the storage period. The lower levels could be attributed to the several factors such as the addition of the preservative, sodium benzoate and also packing in aluminum foil and LDPE pouches that limited entry of moisture and gas during the storage period. Plate count values showed progressive increase throughout the study period but they were found to be well within the sanitation standard of 3 x 10^6 CFU g^{-1} for frozen seafood's [26].

From the present study the meat balls prepared using smashed potato starch was found to have higher nutritive values. TVB-N was found to be more or less similar in both the meat balls with marginally higher values in the meat balls made using smashed potatoes. But the values does not reflect the mode of spoilage whether it is autolytic or microbial. The overall acceptability for the meat balls with smashed potatoes as starch was found to be more from the organoleptic results.

There was significant difference between the organoleptic characters along with days ($P<0.05$). The overall acceptability of the meat balls with smashed potatoes was higher than the ones with Bengal gram starch. From the study it can be concluded that the meat balls prepared using both the starches were good for consumption throughout the study period. The study suggests that meat balls can be prepared from octopus meat and could be stored for long periods, with lesser degree of spoilage. The very high protein content and comparatively low lipid content provides a novel source of protein for human consumption in India. The development of more value added products from the octopus meat could lead to the better utilization of this underutilized resource.

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