Development of a Mushroom curry ball as an Alternative protein source for Vegetarians

GSN Fernando*, PABN Perumpuli, SHNT Suwandarathna, KGD Prasadi and V Wijeratne
Department of Food Science & Technology, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka

Abstract
Mushrooms are highly perishable, and pose serious postharvest losses in the peak harvesting periods resulting in an economical loss to the growers. In order to ameliorate this problem, development of some novel value added product from oyster mushroom is highly appropriate. The present study was aimed to develop a curry ball using oyster mushroom, and to evaluate its sensory, microbiological, physicochemical, and storage properties. Four types of mushroom curry balls using different flour mixtures (corn flour, chickpea flour, rice flour and composite mixture of corn flour and rice flour) (18% w/w) were prepared, and their sensory properties (appearance, taste, color, aroma and overall acceptability) were determined using a 5-point hedonic scale. Mushroom curry ball prepared with the incorporation of chickpea flour gave the highest consumer preference, and was selected for further analysis. The data on proximate analysis showed that the developed product is rich in protein (39.64%) and fiber (5.24%), while low in fat (2.01%). Moreover, the shelf-life studies confirmed that the developed product can be kept for three months of period under -18°C without any deterioration in the quality. Thus, the mushroom curry ball can be developed with chickpea flour, which may be an alternative to meatballs for vegetarians.

Keywords: Chickpea flour, Mushroom, Proximate analysis, Sensory evaluation, Shelf-life
Corresponding author:askgsn@gmail.com

Introduction

Recently, the production and the consumption of mushroom have been tremendously increased mainly due to the awareness of their nutritive value, medicinal attributes, and unique organoleptic characters. The global mushroom production was estimated at about 2.18 to 3.41 million tons over the period of 1997-2007 (FAO, 2015). Currently, about 20 different species of mushroom are commercially cultivated throughout the world. Oyster mushroom (*Pleurotus spp.*), abalone mushroom (*Pleurotus spp.*) paddy straw mushroom and button mushroom (*Agaricus bisporus*) are the most popular commercially cultivated species in Sri Lanka.

Mushrooms are a good source of high quality protein, especially rich in lysine. Mushroom can be used as a source to combat the protein malnutrition in the cereal–dependent developing countries like Sri Lanka (FAO, 2015). Mushrooms are low-calorie, high protein diet, with no starch and sugars, and are called the diabetics delight. Edible mushrooms also provide a nutritionally significant content of vitamins (B1, B2, B12, C, D and E) (Heleno *et al.*, 2010) and iron. Mushroom is a good source for vegetarians since; many nutrients can be supplied by a single diet. Moreover, mushrooms are rich in fiber and alkaline elements that suit to overcome the hyperacidity and constipation conditions. Edible mushrooms could be a source of many different nutraceuticals such as unsaturated fatty acids, phenolic compounds, tocopherols, ascorbic acid, and carotenoids. Thus, they might be used directly in diet to promote health by taking advantage of the additive and synergistic effects of all the bioactive compounds present (Barros *et al.*, 2008).

Mushrooms are highly perishable with a short shelf-life under ambient temperature, environment and humidity conditions. Therefore, it is necessary to develop suitable preservation techniques to prolong the storage. Presently drying, canning and pickling are used as popular long-term preservation techniques of mushroom. But there is a possibility to introduce novel value added products using surplus production of mushrooms during the peak harvesting periods rather than using conventional type preservation methods. Present study was focused to develop a curry ball using oyster mushroom to reduce the postharvest losses, as well as to enhance the income of the mushroom growers. Sensory attributes, overall storage stability, microbiological qualities, and available nutrients of the developed product were evaluated.

Materials and methods

The oyster mushroom (*Pleurotus ostreatus* L.) was collected from local farmers in southern region of Sri Lanka.

Oyster mushroom was washed with clean running water to remove external dust particles and to reduce the microbial load on the surface of the mushroom. Mushroom was steam cooked (100°C) for 10 min, and was crushed by using food processor (KA-SKA3002, Singer, Sri Lanka). Crushed mushroom (66% w/w) was mixed with flour (T_1-corn, T_2-chickpea,T_3- rice and T_4- mixture of corn, rice and chickpea in same proportion)(18% w/w), margarine (5% w/w), garlic (3.5% w/w), onion (5% w/w), salt powder (1.5% w/w) and pepper powder (1% w/w) using the food processor. Mixture was divided into 15 g balls and steamed cooked (100°C) for 20 min. After cooling to the room temperature, the developed curry balls were packed in low density polyethylene (LDPE) bags (gauge 300), and stored in a deep freezer (-18°C).

Sensory evaluation of four different freshly prepared mushroom curry balls was carried out using 30 semi trained sensory panelists using five point hedonic scales. The results of the sensory evaluation were analyzed using Kruskal Wallis Non-parametric one-way ANOVA method with STATISTIX software (Version 20.0). The best sample selected through sensory analysis was further subjected to analyze the proximate composition (moisture, ash, crude fat, crude protein, and crude fiber) and shelf-life. The *E. coli* (Brilliant Green Bile Broth) count, total plate count (TPC), yeast and mold count (Sabouraud's Dextrose Agar (SDA)),and Acid value of the mushroom curry balls stored at -18°C were determined initially and in one month intervals up to three months of period.

All the experiments were conducted in duplicate to draw statistically valid conclusions, and a probability value of 5% (α=0.05) was used in statistical analysis.

Results and Discussion

The mean rank scores for the tested sensory attributes (appearance, aroma, color, taste, texture, and overall acceptability) for the four different mushroom curry balls obtained from 30 semi-trained sensory panelists are summarized in the Table 1.

According to the results, aroma, taste, texture, and overall acceptability of the four different mushroom curry balls were not significantly different (P>0.05), while appearance and color of the mushroom curry ball with corn flour (T_1) showed significant difference (P<0.05) from other three treatments. Considering the highest rank values for all the tested sensory attributes, mushroom curry ball with chickpea (T_2) was selected as the best (Table 1). This could be due to functional properties of chickpeas that contribute to structural, emulsifying, binding and gelling qualities of a product as well as due to colour and flavor (Azham, 2011).

The processing condition and the formulation of curry balls include cooking temperature and ingredients such as salt, fat and water that can have significant effects on product qualities (Huda *et al.*, 2010). Therefore, the proximate composition is important to have idea about the status of product quality. The results of the proximate composition revealed that chickpea added mushroom curry balls contain 71.45% moisture, 2.53% ash, 2.01% fat, 5.24% crude fiber and 39.64% protein amount. The protein content of commercially available chicken meatballs ranged from 7.39 to 13.52%, and above results showed that the mushroom curry ball with chickpea is having higher protein content than the commercially available chicken meat balls. Further, the fat content of the developed curry ball was lower than that of commercially available meat balls (13-15%). In addition, the developed product is a rich source of crude fiber (5.24%).

Generally, indicator microorganism can be used

Table 1: Mean rank values of mushroom curry balls developed using different types of flours

Sample	Appearance	Aroma	Color	Taste	Texture	Overall Acceptability
T_1	49.267 ± 1.14^a	56.417 ± 1.10^a	47.433 ± 0.85^a	50.033 ± 1.18^a	50.667 ± 1.17^a	52.133 ± 1.17^a
T_2	84.233 ± 1.01^b	68.933 ± 1.21^a	77.533 ± 1.00^{ab}	65.967 ± 1.14^a	63.217 ± 1.06^a	69.500 ± 1.17^a
T_3	57.483 ± 1.07^b	55.250 ± 1.07^a	54.900 ± 0.94^b	58.917 ± 0.88^a	60.967 ± 0.90^a	56.067 ± 0.90^a
T_4	51.017 ± 1.01^b	61.400 ± 0.97^a	62.133 ± 0.76^b	67.083 ± 1.06^a	63.217 ± 1.25^a	64.300 ± 0.92^a

T_1-Mushroom curry ball with corn flour, T_2-Mushroom curry ball with chickpea flour, T_3-Mushroom curry ball with rice flour, T_4-Mushroom curry ball with composite flour mixture (corn flour, rice flour and chickpea flour)
Means with same superscripts within the same column are not significantly different from each other at α-0.05 level.

to estimate the potential safety and quality of a crushed product such as curry balls and meatballs (Siriken *et al.*, 2009). Higher Total plate count (TPC) usually relates to poorer quality, and reduces shelf-life. In the present study, *E. coli* was not detected in mushroom curry balls during storage, and thus showing hygienic production procedure and acceptability for consumption. Moreover, the TPC and the yeast and mold count ranged between 1 to 10^1 and 10^{-1} to 10^1 CFU/g, respectively, during the three months of storage period under deep freezer (-18^{0}C). Also the acid value which represents the rancidity of the developed product did not exceed 0.5 mg KOH/g during the three months of storage period. Therefore, developed product can be considered for safe consumption until three months of period.

Conclusions

Mushroom curry ball prepared with chickpea flour had higher mean rank values for sensory properties of appearance, aroma, color, texture, and overall acceptability, compared to other types of mushroom curry balls. According to the microbiological and acid value analysis, shelf-life of the developed product was reported to be 3 months under frozen condition (-18^{0}C) in polyethylene pouches. The developed product was rich in protein and crude fiber. Finally, it can be concluded that mushrooms can successfully be used to develop curry balls as an alternative to the meatballs.

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