Process optimization and characterization of ‘sev’ (traditional Indian extruded snack) with the incorporation of mushroom powder

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Abstract Mushroom is a nutritious and palatable food with various health attributes. The mushroom powder is a rich source of vegetable protein. In the present study, efforts were made to optimize the process for making ‘sev’, a traditional Indian extruded snack, with the incorporation of mushroom powder (*Agaricus bisporus*) to the Bengal gram (*Cicer arietinum* L.) flour (‘besan’). Response surface methodology with central composite rotary design was used to determine the optimum level of various ingredients for ‘sev’ which was then analyzed for various physico-chemical and sensory characteristics. Storage studies of mushroom ‘sev’ (with and without rice starch/mashed potato) were done at 37 ± 1 °C. The product containing rice starch was found to be highly acceptable over that with mashed potato. The optimized mushroom ‘sev’ contains 7.93% mushroom powder, 8.91% rice flour, 75.95% Bengal gram flour and 7.2% other ingredients with high scores for different sensory attributes viz., colour (8.4), appearance (8.3), flavour (8.3), texture (8.5) and overall acceptability (8.4). The mushroom powder based ‘sev’ had 2.79% higher protein content than the control sample (without mushroom powder) with a storage life of at least 7 days at 37 ± 1 °C.

Keywords *Agaricus bisporus* · Bengal gram flour · Besan · Mushroom powder · Sev

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Introduction

India has a big market for savoury snacks which grew at a CAGR of 29.04% during the period 2010–2015 and has expected CAGR of 33.59% during the period 2015–2020 and the market value is expected to reach INR 1,410,936.0 million by 2020 (MoFPI 2017). Ethnic and traditional snacks are the largest category in the Indian savoury snacks market. ‘Sev’ is such an Indian traditional extruded, deep fat fried snack which is popular throughout the country (Pruthi et al. 1983). Traditionally, it is prepared from Bengal gram/chickpea (*Cicer arietinum* L.) flour (‘besan’) with additives such as salt, spices and sodium bicarbonate. Some additives are added to impart crisp and crunchy texture to the fried product (Berry et al. 1986). Rice flour is a good source of starch and is used to impart crispiness. Similarly, potato (*Solanum tuberosum* L.) is a good source of starch which may be used to replace rice flour to impart texture to the ‘sev’ as it is comparatively cheap. Potato contributes calories, vitamins (vitamin C) and minerals to the Indian rural households especially when the supplies of other vegetables are low. India is the second largest producer of potato in the world after China (Scott and Suarez 2012). In the food industry, potato is generally used for the manufacture of snacks such as chips (mainly in India) and french-fries (mainly in China) in addition to the manufacturing of starch (Bond 2014). As flour, it may also be incorporated in biscuits and snacks (Nayak et al. 2011).

Mushroom is a nutritious and palatable food. It is low in calories, fats and high in vegetable proteins as well as vitamins and minerals. The protein content of the fresh mushroom (*Agaricus bisporus*) is 2–3% (Mattila et al. 2002) while it varies from 32 to 42% on dry weight basis (Hayes and Hadad 1976). Mushroom protein is intermediate in quality between vegetables and animal proteins and the

supplementary value of mushroom protein in vegetarian diet is of considerable significance (Verma et al. 1987). Mushrooms have been found effective against cancer, cholesterol reduction, stress, insomnia, asthma, allergies, diabetes (Bahl 1983) and HIV (King 1993). Due to low starch and fat content, they suit diabetic and heart patients. Biologically active compounds from the mushrooms possess antifungal, antibacterial, antiviral and antioxidant properties (Wani et al. 2010; Lakshmi et al. 2005). Thus, mushrooms offer tremendous applications as health food. Studies have been done by some researchers in the past to utilize mushroom in different products to increase its consumption for example, Kaur et al. (2013) developed pasta enriched with mushroom powder, Bengal gram flour and defatted soy flour while Bahri and Rosli (2016) developed herbal seasoning with the addition of mushroom powder.

Keeping in view the tremendous value of mushrooms, the present study was undertaken to incorporate mushroom powder in 'sev' in order to not only diversify utilization of mushroom but also to bring value addition and improvement in the nutritional value of 'sev'. Ingredients were optimized for the preparation of 'sev' with the incorporation of mushroom powder (*Agaricus bisporus*).

Materials and methods

Fresh mushroom (*Agaricus bisporus*) was procured from Mushroom Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar and M/s Tarai Food Limited, Rudrapur and kept in refrigerator ($5 \pm 1^\circ\text{C}$) and was used within 24 h of harvest. Bengal gram flour (Rajdhani brand 'besan'), Rice (Indrasan variety), potato, refined groundnut oil (Nature Fresh brand), hydrogenated vegetable fat (Gagan brand) and spices were purchased from the local market.

Mushroom powder was made by washing mushroom in water, cutting into 3 mm thick slices followed by blanching in boiling brine (2% NaCl) for 3 min, cooling in chilled water and steeping in 0.5% potassium meta bisulphite (KMS) at room temperature for 30 min. Steeped mushrooms were drained to remove surface water, spread on trays and dried for 12 h at $60 \pm 2^\circ\text{C}$ in an air tray drier. On cooling, the dried mushrooms were ground in a grinder and powder was passed through 80 mesh sieve. The resultant powder was packed in air tight PET jar and kept at room temperature.

To make rice flour, rice grains were cleaned, washed with water followed by drying in hot air oven at about 70°C for half an hour and on cooling were ground in a grinder and then passed through 80 mesh sieve. The sieved flour was kept in air tight containers. When mashed potato was used as starch source, potatoes were first washed, boiled, peeled and then mashed and used fresh.

Response Surface Methodology (RSM) with central composite rotary design (CCRD) was used to determine the optimum level of various ingredients for 'sev'. The range of the ingredients was based on the preliminary experiments (details are not given here). The experimental plan for two independent variables (mushroom flour and starch source) and one dependent variable (Bengal gram flour) consisted of twelve experiments (Table 1) was conducted first for rice flour and then same set of another twelve experiments were performed with mashed potato as source of starch. The first four experiments were in the first order part, next four experiments were in the second order part and the last four experiments were at the centre point. The coded and uncoded terms are also given in Table 1. In each experiment, the quantity of mushroom flour, starch source (rice flour or mashed potato) and Bengal gram flour was taken as per the RSM design and then 92.8 g of this mix was blended with 7.2 g of the following other ingredients (fixed variable) to form 100 g of blend:

Common salt: 3.0 g.
Red chilli powder: 0.5 g.
Turmeric powder: 0.5 g.
Hydrogenated vegetable fat: 3.0 g.
Sodium bicarbonate: 0.2 g.

All the ingredients were taken in plastic bowl, mixed well in dry state and then kneaded with adequate amount of water so as to yield soft and pliable dough. The dough was extruded through manually operated 'sev-press' directly into a frying pan. About one litre of frying oil was taken in frying pan and its temperature was raised to $180 \pm 5^\circ\text{C}$. Frying was considered complete when frothing in the oil seized. By this time, the product has puffed maximum with maximum moisture reduction. At the end of frying time, 'sev' were taken out of the pan and held above the oil for a short period to allow excess oil to drain back into the pan. Then 'sev' were spread over plain white paper to remove excess oil from the surface, cooled to room temperature, packed in polythene bags and were kept at room temperature. Samples were subjected to sensory evaluation to a panel of 9 panelists from the Department of Food Science and Technology, Pantnagar. Effect of different levels of mushroom powder and rice flour on the sensory responses was studied using second order polynomial. Full second order equation (Eq. 1) was fitted in each response to describe it mathematically and to study the effect of levels of ingredient on it:

$$Y = a_0 + a_1X_1 + a_2X_2 + a_{12}X_1X_2 + a_{11}X_1^2 + a_{22}X_2^2 \quad (1)$$

where Y , Response variable, i.e., score for sensory attributes; X_1 and X_2 , coded level of independent variables, i.e., mushroom flour and starch source and a_0 , a_1 , a_2 , a_{11} , a_{12} , are constant coefficients. The adequacy of the model was tested using coefficient of determination (R^2).

Table 1 The experimental design matrix based on RSM for ‘sev’ preparation and level of ingredients in coded and uncoded form

Experiment no.	Coded values		Uncoded values (g)		
	X ₁	X ₂	X ₁ Mushroom flour	X ₂ Starch source ^a	Bengal gram flour
<i>First order part</i>					
1	− 1	− 1	2.93	6.465	90.605
2	− 1	+ 1	2.93	13.535	83.395
3	+ 1	− 1	17.07	6.465	76.365
4	+ 1	+ 1	17.07	13.535	69.395
<i>Second order part</i>					
5	− α	0	0	10	90.00
6	+ α	0	20	10	70.00
7	0	− α	10	5	85.00
8	0	+ α	10	15	75.00
<i>Third order part</i>					
9	0	0	10	10	80
10	0	0	10	10	80
11	0	0	10	10	80
12	0	0	10	10	80

^aStarch source: rice flour or mashed potato

The optimized ‘sev’ was analyzed for water requirement for dough preparation, oil uptake, yield, expansion ratio, proximate composition, free fatty acids (FFA) and peroxide value (PV). To determine water requirement for preparing ‘sev’ dough, measured quantity of water was added to the dry blend using a pipette till dough of soft and pliable consistency was obtained. Fat content and oil uptake by ‘sev’ during deep fat frying was measured by soxhlet method (SOXTEH HT-2 system) using petroleum ether (boiling point 40–60 °C) as solvent (AOAC 1995). The oil uptake of product was expressed as g oil/100 g sev. To determine the final yield of the deep fat fried ‘sev’, weight of total product obtained from a known quantity of blend was measured and results expressed as g/100 g blend. To calculate the expansion ratio (ER), diameter of the ‘sev’ was measured using screw gauge (mm) and this value was divided by the diameter of the orifice of ‘sev’ press (2 mm). Moisture content was determined by hot air oven method (AOAC 1995). The protein content of samples was determined by micro Kjeldhal method (AOAC 1995). Conversion factor of 4.38 was used for both mushroom and mushroom powder and a factor of 5.95 was used for rice while a factor of 6.25 was used for all other samples. Total ash was determined by AOAC (1995) method using muffle furnace at 550–600 °C. Carbohydrate content was calculated by subtracting the sum of moisture, protein, fat and ash from 100.

Water activity (a_w) and shelf life (at 37 ± 1 °C) of the optimized ‘sev’ was determined. Stored samples were subjected to sensory evaluation and analyzed for FFA at

intervals of 0, 7, 14 and 21 days using AOAC (1995) method with little modifications. To determine free fatty acid, about 10–20 g sample of ‘sev’ was taken in a 250 ml conical flask. To it, 150–200 ml of petroleum ether was added and oil from sample was extracted by keeping it for about 60 min with occasional shaking. Miscella was collected in another 100 ml conical flask, 20 ml of this miscella was taken in pre weighed dried petridish and was kept in hot air over at 80 °C for 2 h, and the weight of the oil was calculated. To another 20 ml of the miscella, 10 ml of neutral ethanol was added and the mix was titrated against N/10 NaOH, with phenolphthalein as indicator.

FFA (as % oleic acid)

$$= \frac{\text{Titre value} \times \text{normality of NaOH} \times 0.282 \times 100}{\text{Weight of oil in miscella}}$$

Data from the optimization studies in RSM experiments were analyzed with the help of Design Expert software (Version 11). The data generated during the storage studies were subjected to analysis of variation (ANOVA) with the help of Microsoft Excel-2000 software.

Results and discussion

The proximate composition of mushroom flour, Bengal gram flour, rice flour and mashed potato used in the preparation of deep fat fried ‘sev’ is given in Table 2. It can be seen that the mushroom flour has the highest level of

Table 2 Proximate composition of raw materials, control ‘sev’ and optimized mushroom flour-rice flour-sev

Constituents	Mushroom flour	Bengal gram flour	Rice flour	Mashed Potato	Control sev	Optimized mushroom flour-rice flour-sev
Moisture (%)	7.15	9.75	9.64	81.35	3.24	3.87
Protein (%) ^a	35.29	21.20	7.99	5.80	12.28	15.07
Fat (%)	3.20	5.00	0.57	0.16	27.41	31.92
Ash (%)	8.40	2.61	0.57	1.02	4.52	4.60
Carbohydrate (% by difference)	45.99	61.44	81.23	11.67	52.55	44.54

^aFactors for mushroom: 4.38; rice flour: 5.95; others: 6.25

protein and ash (mineral) content amongst all the ingredients.

Physical characteristics of mushroom ‘sev’

The physical characteristics for rice flour based mushroom ‘sev’ prepared from different flour blends were determined. Figure 1 shows the graphical representation of the 3-D surfaces for different physical attributes for ‘sev’ made from mushroom flour, rice flour and Bengal gram flour. Water required to prepare dough for control sample was 40 ml. The dough preparation from the other 12 blends required 42.8 ml to 59 ml of water whereas, their dough moisture content ranged from 29.9 to 38.5% as compared to a moisture level of 28.6% in control sample. The different samples had an oil uptake of the range of 39 to 58 ml while the frying time ranged from 39 to 52 s. The control sample had an expansion ratio of 1.50 and had a yield of 106.6 g/100 g of blend. The yield of the other 12 blends ranged from 109.6 to 134.6 g. The maximum yield was obtained in case of a flour blend having the composition of 17.07 g mushroom flour, 13.535 g of rice flour and 69.395 g of Bengal gram flour. The expansion ratio for the other 12 blends ranged from 1.43 to 1.53 with the maximum expansion being in the case of blend containing 10 g mushroom flour, 15 g rice flour and 75 g Bengal gram flour. On feeding the responses obtained for physical parameters along with the sensory scores in the RSM design and setting the criteria for ‘goal’ as ‘maximise’ for expansion ratio, colour and overall acceptability (while other responses at ‘none’), the optimum solution obtained was 8.797 g mushroom flour and 9.633 g rice starch with a desirability of 0.846. However, on further modifying the criteria for ‘moisture in dough’ to ‘minimize’ along with preset goal of ‘maximise’ for expansion ratio, colour and overall acceptability (and other responses at ‘none’) the solution obtained was 7.963 g mushroom flour and 9.025 g rice starch with a slightly lower desirability of 0.824.

Different physical characteristics of potato solids-based mushroom ‘sev’ were determined. The water requirement for the dough preparation from 12 different blends ranged

from 0 to 20 ml. The maximum water requirement was in the case of experiment number 9, 11 and 12, all containing 10 g mushroom flour, 10 g potato solids and 80 g Bengal gram flour. The corresponding values of moisture in the dough prepared from 12 different blends were found to range from 22.4 to 31.3%. The dough prepared from control blend had a moisture content of 28.6%. The oil uptake for different combinations of flour blends ranged from 44 to 64 ml while the frying time was found to range from 46 to 62 s. The dough when extruded for frying had the expansion ratio in the range of 1.33 to 1.44 where as the control sample had an expansion ratio of 1.50. The yield of ‘sev’ from 12 different blends ranged from 104.4 to 119.2 g. The maximum yield was found in the case of ‘sev’ made from blend containing 17.07 g mushroom flour, 13.535 g potato solids and 69.395 g Bengal gram flour.

Sensory characteristics of mushroom ‘sev’

The sensory liking for the ‘sev’ made from the different 12 blends containing varied proportions of mushroom flour, rice flour and Bengal gram flour as per RSM design ranged over ‘liked slightly’ to ‘like very much’ (scores ranging from 6.2 to 8.4) while the corresponding liking for the ‘sev’ made from the other 12 blends containing varied proportions of mushroom flour, mashed potato and Bengal gram flour was lower (ranged over scores 5.6 to 7.9) suggesting the higher acceptability of rice flour as the source of starch over mashed potato in the ‘sev’.

The regression equations obtained for different sensory attributes for the ‘sev’ made from mushroom flour, rice flour and Bengal gram flour are as follows:

For colour,

$$Y_1 = 8.30 - 0.141 X_1 - 0.1 X_2 - 0.638 (X_1)^2 - 0.688 (X_2)^2 + 0.2 X_1 X_2 \quad (R^2 = 90.7\%) \quad (2)$$

For appearance,

Fig. 1 3-D surfaces for different responses for physical attributes of rice flour-based mushroom ‘Sev’

$$Y_2 = 8.28 - 0.4 X_1 - 0.05 X_2 - 0.856 (X_1)^2 - 0.606 X_2^2 + 0.025 X_1 \cdot X_2 (R^2 = 93.7\%)$$

For flavour

$$Y_3 = 8.18 - 0.264 X_1 - 0.286 X_2 - 0.688 (X_1)^2 - 0.563 (X_2)^2 + 0.375 X_1 \cdot X_2 (R^2 = 93.4\%)$$

For texture,

$$Y_4 = 8.25 - 0.214 X_1 - 0.180 X_2 - 0.488 (X_1)^2 - 0.913 (X_2)^2 + 0.175 X_1 \cdot X_2 (R^2 = 84.6\%)$$

For overall acceptability,

$$Y_5 = 8.28 - 0.3246 X_1 - 0.1479 X_2 - 0.8188 (X_1)^2 - 0.7687 (X_2)^2 + 0.125 X_1 \cdot X_2 (R^2 = 95.5\%)$$

where Y_1 , Y_2 , Y_3 , Y_4 , and Y_5 denote sensory scores for colour, appearance, flavour, texture and overall acceptability and X_1 and X_2 are levels of mushroom flour and rice flour respectively. Since all the values of R^2 are more than 80%. Therefore, all the above models were considered fit for analysis.

Establishment of optima on the basis of sensory responses for mushroom flour ‘sev’ with rice starch

Figure 2 shows the graphical representation of the 3-D surfaces for different sensory attributes for ‘sev’ made from mushroom flour, rice flour and Bengal gram flour.

Colour

The effect of individual variables i.e., levels of mushroom flour and rice flour and their interaction on colour showed negative linear effect at 5% level of significance (Eq. 2). The colour score decreased with increase in mushroom flour level. Both mushroom flour and rice flour on quadratic terms showed significant negative effect on colour. The interaction between both variables affected the colour positively but the effect was non significant.

Optimization of ingredients resulted in an estimated optimum colour score of 8.32 and the corresponding ingredient levels were mushroom flour (8.63 g), rice flour (9.90 g) and Bengal gram flour (81.47 g). On neglecting the non significant terms Eq. (2) becomes,

$$Y_1 = 8.30 - 0.141 X_1 - 0.638 (X_1)^2 - 0.688 (X_2)^2 \quad (7)$$

Fig. 2 3-D surfaces for different sensory responses of rice flour-based mushroom ‘Sev’

Appearance

There was a non significant linear effect of the individual variables on appearance, but on quadratic terms both the variables showed a highly significant ($P \leq 0.01$) negative effect (Eq. 3). It shows that the appearance score decreased with increasing level of both the variables. There was a non significant effect of both the variables on appearance at interactive level.

Optimization of ingredients for appearance resulted in estimated optimum appearance score of 8.31 and the corresponding ingredient levels for mushroom powder, rice flour and Bengal gram flour were 9.054, 9.341 and 81.615 g, respectively. The following equation was obtained after omitting the non significant terms in Eq. (3).

$$Y_2 = 8.28 - 0.856 (X_1)^2 - 0.606 (X_2)^2 \quad (8)$$

Flavour

The effect of individual variables (mushroom and rice flour) on flavour showed significant negative linear effect at 5% level (Eq. 4). Their effect was highly significant at $P \leq 0.01$ at quadratic level. Thus the flavour decreased with increase in levels of the above two ingredients. The interaction between the variables had a significant positive effect at 5% level.

The optimization of ingredients for flavour resulted in an estimated flavour score of 8.26 and the corresponding level of ingredients were found to be 7.683 g for mushroom flour, 8.950 g for rice flour and 83.367 g for Bengal gram flour.

Texture

There was a significant negative effect of mushroom flour on texture at linear terms at 5% level (Eq. 5). It was observed that increasing the mushroom flour level made ‘sev’ hard and consequently decreased the texture score (Fig. 2). Both, mushroom flour and rice flour, were found to have significant negative effect at quadratic terms, at 5.0% and 1.0% levels, respectively but their interaction was found to be non significant.

A calculated optimum texture score of 8.31 was obtained at the optimum ingredient levels, i.e., mushroom flour 7.458 g, rice flour 9.771 g and Bengal gram flour (82.771 g) respectively. After omitting the non significant terms Eq. (5) for texture becomes.

$$Y_4 = 8.25 - 0.214 X_1 - 0.488 (X_1)^2 - 0.913 (X_2)^2 \quad (9)$$

Table 3 Effect of storage under different relative humidities on equilibrium moisture content (EMC) and physical characteristics of mushroom based ‘sev’ with rice flour

Relative humidity (%)	EMC (% db)	Days for equilibration	Remarks
11.2	2.27	11	Golden yellow very crisp and hard
22.0	2.89	8	Golden yellow very crisp and hard
32.4	3.69	7	Golden yellow crisp
43.5	6.47	9	Golden yellow slightly crisp
52.0	7.04	11	Golden yellow slightly crisp
63.3	9.86	12	Dull yellow soft
71.4	12.26	11	Faded yellow soft
79.6	ND	13	Blackened due to mould attack
92.0	ND	4	Blackened due to mould attack

ND: could not be done due to spoilage

Overall acceptability

Mushroom flour had a highly significant negative effect in linear terms while rice flour had a non significant effect (Eq. 6). It shows that increase in the level of mushroom flour decreased the overall acceptability of ‘sev’. Both mushroom and rice flour at quadratic terms had a highly significant negative effect ($P \leq 0.01$). The interaction between both variables had a non significant effect on texture. Equation (6) for overall acceptability score after omitting the non significant term becomes:

$$Y_5 = 8.28 - 0.325 X_1 - 0.819 (X_1)^2 - 0.769 (X_2)^2 \quad (10)$$

Optimization of ingredients for the overall acceptability (‘goal’ set as ‘maximise’) resulted in an estimated optimum overall acceptability score of 8.32 and the corresponding levels were mushroom flour 8.538 g, rice flour 9.600 g and Bengal gram flour 81.862 g (with very high desirability 0.962). As it formed 92.8% of the optimized dry mix containing 7.2% other ingredients (as detailed in method and materials section), therefore on recalculating, the optimized ‘sev’ contains 7.93% mushroom powder, 8.91% rice flour, 75.95% Bengal gram flour and 7.2% other ingredients.

The optimized solution suggested above on the basis of physical property (expansion ratio), colour and overall acceptability was also close to these values for mushroom flour and rice starch. Therefore, for an estimated optimum overall acceptability score (8.32), the levels of independent variables viz. mushroom flour, rice flour and dependent variable (Bengal gram flour) along with fixed variable (other ingredients, 7.2%) was considered as the optimum level to develop the optimized ‘sev’.

Proximate analysis of optimized ‘sev’ and its nutritional importance

The optimized ‘sev’ made from 7.93% mushroom powder, 8.91% rice flour, 75.95% Bengal gram flour and 7.2% other

ingredients was analyzed for its proximate composition. Proximate composition of the optimized ‘sev’ and the control sample is shown in Table 2. The protein content of the ‘mushroom-sev’ was found to be 15.07% which is 2.79% more than the control sample. Greater oil absorption was found in samples containing mushroom flour and rice flour. The ‘sev’ containing mushroom and rice flour had a fat content of 31.92% while control sample had a fat content of 27.41%. Carbohydrate (by difference) was found to decrease due to increased level of other parameters in the optimized ‘sev’ (Table 2). However, ‘mushroom-sev’ provides higher energy (537.64 kcal/100 g) than the control sample (518.98 kcal/100 g) and therefore, can serve as an energy rich nutritious snack to Indians particularly targeting the protein-energy malnutrition (PEM). According to the National Family Health Survey (2015–2016), the prevalence of stunting, wasting and underweight amongst children under 5 years is 38.4%, 21.0% and 35.7%, respectively. PEM affects the chances of survival for children, their learning abilities and later, their job performance. India has still to go long way to overcome it and consumption of ‘mushroom-sev’ may help in two ways. First, the health status of the population may improve and second, the farmers may earn more income with the sale of mushrooms as its production does not require arable land and mushroom cultivation can be done indoors on agricultural wastes like wheat straw, paddy straw and other straws (Khanna and Kapoor 2016).

Water activity (a_w) of mushroom ‘sev’

The optimized mushroom based ‘sev’ was found to loose moisture when stored under relative humidity (RH) $\leq 32.4\%$ whereas it gained moisture at higher RH values (Table 3). ‘Sev’ retained its golden yellow colour up to 52.0% RH but the colour of sample stored at 63.3% RH became dull and further faded at 79.6% RH. Under RH of 43.5 and 52.0% the product retained crispness slightly though the moisture content increased up to 7.04%. Sample

Table 4 Storage changes in mushroom 'sev' during storage at 37 ± 1 °C

Storage period		Sensory score for ^a				
Days	FFA (% oleic acid)	Colour	Appearance	Flavour	Texture	Overall acceptability ^b
<i>Control 'sev' from Bengal gram flour only</i>						
0	0.40	7.8	7.5	7.6	7.8	7.7
7	0.46	7.1	7.0	7.0	7.2	7.1
14	0.59	7.0	7.0	5.5*	5.5*	6.0*
<i>Rice based mushroom sev</i>						
0	0.44	8.4	8.3	8.3	8.5	8.4
7	0.48	8.0	8.0	7.2	7.2	7.6
14	0.61	8.0	8.0	5.0*	5.5*	6.5 ns
<i>Potato solids based mushroom sev</i>						
0	0.49	7.0	7.4	7.2	7.2	7.2
7	0.54	7.0	7.2	6.1	6.4	6.7
14	0.67	7.0	7.0	5.0**	4.5 ns	6.0 ns
<i>Plain mushroom sev</i>						
0	0.42	8.0	8.2	8.2	8.2	8.1
7	0.48	8.0	8.0	7.6	7.2	7.7
14	0.51	8.0	8.0	6.5 ns	6.5*	7.2 ns

* $p < 0.05$, ** $p < 0.01$, ns non-significant

^aMaximum score 9 for like extremely and 1 for dislike extremely

^bAverage of scores for color, appearance, flavour and texture

kept at 63.3% RH had 9.86% EMC was found to be of soft texture and unacceptable. Though the samples stored under RH up to 32.4% remained very crisp but the samples with EMC less than 3.69% were found to be of hard texture. Berry et al. (1986) had reported potato 'sev' to retain crispiness up to 4.0% moisture level (dry wt. basis) which is close to the ERH value of 3.69 found in the present study.

Storage changes in mushroom sev

Sensory attributes of the control samples of 'sev' deteriorate during storage for 3 weeks at 37 ± 1 °C. In all the sensory attributes, minimum changes took place during first 7 days. And the changes in colour and appearance were also negligible during storage over next week (Table 4). However, during this period, changes were observed in flavour and texture scores and the scores reduced significantly. Panelists termed the product stored for 14 days as rancid and soft. This was also reflected in the FFA of samples which increased from initial value of 0.40 (as % oleic acid) to 0.59 (as % oleic acid). Statistical analysis of the data (ANOVA) showed that there was significant correlation between overall acceptability, flavour and FFA of the samples stored for 14 days.

The optimized 'rice based mushroom sev' (containing 7.93% mushroom powder, 8.91% rice flour, 75.95% Bengal gram flour and 7.2% other ingredients) also followed

the same pattern of changes for the flavor score as the control above (Table 4). However, the colour and appearance score (initially 8.4 and 8.3) changed to 8.0 on 7th day and remained same till 14th day of storage. There was significant correlation between flavour and FFA of the samples. The FFA of the samples stored for 14 days increased to 0.61 from 0.44 as the initial value.

The potato-based mushroom 'sev' also followed the same trend and the increased level of FFA (0.49 and 0.67) has strong correlation with the flavour of the product. The colour score remained the same throughout the storage but the appearance score changed from 7.4 to 7.0. Sev made from mushroom flour and Bengal gram flour did not turn rancid but has lower scores of flavour (6.5), texture (6.5) and overall acceptability (7.2). The FFA level increased from 0.42 to 0.51 (% oleic acid) but the effect was not significant.

Conclusion

In the present study, it was found that the 'sev' prepared with the addition of mushroom powder has high sensory acceptability for different sensory attributes. The 'sev' was optimized for three ingredients viz., mushroom powder, starch source and Bengal gram flour. The optimized 'sev' was prepared from a blend of mushroom powder (7.93%), rice flour (8.91%), Bengal gram flour (75.95%) and other

ingredients (7.2%) and have a protein content of 15.07% which is 2.79% more than that of the control sample (92.8% Bengal gram flour and 7.2% other ingredients). The developed 'sev with mushroom powder' provides higher energy (537.64 kcal/100 g) than the control samples (518.98 kcal/100 g) and therefore, can serve as an energy rich nutritious snack to Indians.

References

- A.O.A.C. (1995) Official methods of analysis, 16th edn. Association of official Analysis Chemists, Washington
- Bahl N (1983) Medicinal value of edible fungi. In: Proceeding of the international conference on science and cultivation technology of edible fungi. Indian Mushroom Science II, pp 203–209
- Bahri SS, Rosli WIW (2016) Effect of oyster mushroom (*Pleurotus sajor-caju*) addition on the nutritional composition and sensory evaluation of herbal seasoning. *Int Food Res J* 23(1):262–268
- Berry SK, Kulkarni SG, Senghal RC, Kaur S, Kalra CL (1986) Studies on the utilization of post cold stored potatoes in the preparation of potato based 'sevia'. *Indian Food Packer* 40:42–49
- Bond JK (2014) Potato utilization and markets. In: Navarre R, Pavsek MJ (eds) *The potato: botany, production and uses*. CAB International, Wallingford, pp 29–44
- Hayes WA, Hadad N (1976) The food value of the cultivated mushrooms and its importance in industry. *Mushroom J* 40:104–110
- Kaur G, Sharma S, Nagi HP, Ranote PS (2013) Enrichment of pasta with different plant proteins. *J Food Sci Technol* 50(5):1000–1005
- Khanna PK, Kapoor S (2016) *Mushroom growing*. Punjab Agricultural University, Ludhiana
- King TA (1993) Mushrooms, the ultimate health food but little research in U.S. to prove it. *Mushroom News* 41:29–46
- Lakshmi B, Tilak JC, Adhikari S, Devasagayan TPA, Janardhanan KK (2005) Evaluation of antioxidant activity of selected Indian mushrooms. *Int J Pharm Biol* 42:179–185
- Mattila P, Salo VP, Konkko K, Aro H, Jalava T (2002) Basic composition and amino acid contents of mushroom cultivated in Finland. *J Agric Food Chem* 50:6419–6422
- MoFPI (2017) High-growth segments of Indian food and beverage industry. MoFPI, E&Y and CII. World Food India, 3–5 Nov, New Delhi
- National Family Health Survey-4 (2015–2016) Ministry of Health and Family Welfare. <http://rchiips.org/NFHS/pdf/NFHS4/India.pdf>. Accessed on 9 Aug 2018
- Nayak B, Berrios JDJ, Powers JR, Tang J, Ji Y (2011) Colored potatoes (*Solanum tuberosum* L.) dried for antioxidant-rich value-added foods. *J Food Process Preserv* 35:571–580
- Pruthi JS, Kalra CL, Manan JK, Raina BL (1983) The manufacturing, packaging and storage of traditional savoury foods, Part II, Phulwadian, mukandawadian and other savoury foods. *Indian Food Packer* 37(6):73–94
- Scott GJ, Suarez V (2012) The rise of Asia as the centre of global potato production and some implications for industry. *Potato J* 39(1):1–22
- Verma RN, Singh GB, Bilgrami KS (1987) Fleshy fungal flora of N. E. H. India- I. Manipur and Meghalaya. *Indian Mushroom Sci* 2:414–421
- Wani BA, Bodha RH, Wani AH (2010) Nutritional and medicinal importance of mushrooms. *J Med Plants Res* 4(24):2598–2604

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