

Optimization and Standardization of Spreadable Cheese Fortified with Mushroom Powder

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The main purpose of this study was to develop spreadable cheese fortified with mushroom powder. Moisture, fat, and protein content were of higher value in fortified cheese supplemented with mushroom powder. The moisture content of fortified cheese was 58.66% while that of control cheese was 52.36%. The protein content of fortified cheese was 29.08%, while that of control cheese was 22.45%, fat content in fortified cheese was 32.2% while that of control cheese was 28.8% and the ash content of fortified cheese was 3.95 % while that of control cheese was 2.72%. The microstructure of mushroom powder, fortified cheese, and spreadable cheese was analyzed through SEM and XRD. Fortified cheese was amorphous. Elements composition of control cheese, fortified cheese, and mushroom powder was also detected through the EDS graph. In this graph different types of elements were found in mushroom powder, spreadable cheese, and fortified cheese. The physic-chemical parameters were studied like Texture, surface, color, aroma, and taste. The product developed was appreciated by the sensory panelist. For further better analysis nutritional properties of spreadable cheese and mushroom powder. And the morphology analysis was done by SEM and XRD.

Keywords: Fortified Cheese; SEM; XRD; EDS; Mushroom Powder; Sensory Assessment**Graphical Abstract****Figure a****Introduction**

In recent years, mushroom has become increasingly apparent all over the world due to their nutritional and medicinal properties. The button mushroom (*Agaricus bisporus*) is one of the most cultivated and consumed all over the world. It contributes about 40% of the world's production [1]. The button mushroom is using different forms among them, mushroom powder is becoming increasingly popular as a food additive and a supplement for other products because of its high nutrition value, low cost, and health benefits. The button mushroom has rich in minerals, and antioxidants, and can reduce the risk of various diseases. Furthermore, studies have shown that mushrooms can relieve symptoms of diabetes and improve cognitive function. The main reason for this growing popularity is that it has been found that mushrooms can be a potent source of selenium (organic sulfur-containing compound) which is an essential mineral with important physiological functions in living organisms, as well as immune system support, cancer prevention, cardioprotection, and anti-aging [2]. One

of the bigger problems with this mushroom crop is that they are very hard to cultivate because they require significant maintenance and produce low yields. Despite these difficulties, more and more people are attracted by their nutritive benefits [3].

Cheese is a widely demanded dairy product around the world. Between 2015 and 2020, India's cheese market grew at a rapid pace. Manufacturers developed a variety of flavoured cheese, such as oregano, salt, garlic ginger, and so on. Changing eating habits are leading to an increase in cheese demand [4]. There has been an increasing demand for healthy cheese, even though there is still very little research available dealing with the use of fruits and vegetable by-products to fortify dairy products. Spreadable cheese has been mild to mellow in flavour and be made with pasteurized and standardized milk. soft fresh spreadable cheese that has a creamy smooth texture, that are allowing the cheese to be easily spread onto other foods like vegetables, fruits, bread, etc. Spreadable cheese is naturally soft. It has a higher moisture content [5] Protein, fat, and water (brine) are three key ingredients found in all cheeses, and they all affect the structural and rheological aspects of the cheese. It's a concentrated dairy product made by coagulating milk with rennet enzyme or acid, stirring, then boiling the curd, draining the whey, then collecting and pressing the curd. The texture and flavour of the cheese developed as it ripened. These cheeses have a smooth texture, are soft and white, and have a limited shelf life [6]. Mushroom is a cheap and tasty food with high nutritive value, particularly on protein (2-5%) and 30-40% when dried [7]. Mushrooms meals dietary supplements, they're rich supply of very excessive first-class proteins and critical amino acids; a suitable supply of pro-vitamin D and most of the B vitamins. Essential unsaturated fatty acids represent 72% of the overall fatty acids; Linoleic acid is an extensive element in regarding mushrooms as a healthy meal [8]. The spreadable cheese found in calcium it has contributes to body weight loss and provides protection against breast cancer and metabolic syndrome, which is a group of conditions that increase the risk of developing heart disease [9]. The study's main objective to the development of fortified cheese was to examine the morphological properties of mushroom powder and fortified cheese and to study the sensory properties of fortified cheese.

Material and Methods

Material

The experiment was carried out at the Food Science and Technology Laboratory, Babasaheb Bhimrao Ambedkar University Lucknow, U.P., India. In this study, two-liter milk was used as raw material for cheese production. The edible mushroom/button mushroom was procured from the Button mushroom spawn, Luc-

know (U.P), Vinegar (acetic acid), salt (NaCl), and pepper powder were taken from the local market of South city, Lucknow, U. P.

Equipment

Weighing Machine (Model no: WENSAR, AN ISO 9001:2015 Company), Measuring Cup, Food Thermometer, Mixer, Sieve, Fridge, etc.

Experimental procedure

Preparation of mushroom powder

The mushroom was washed with tap water (three time) and further cut into small slices. Afterward, sample was dry in the presence of sun (time: 2 days) and then grinded using an electric blender to powder form and sample was stored in airtight container.

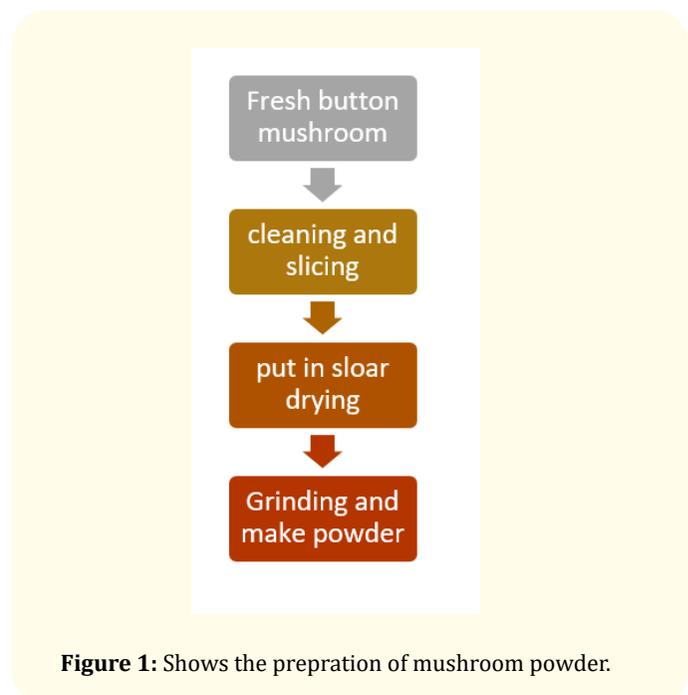


Figure 1: Shows the preparation of mushroom powder.

Preparation of spreadable cheese

During the development of spreadable cheese, milk was standardized to 4.2% fat and pasteurized to 72°C for 15 seconds, then stored overnight at cooling at less than 10°C temperature. The next day milk was warmed to below 20°C. When the milk temperature rises to 50°C and added 150ml acetic acid with continuous agitation to maintain pH-5.9. Afterward, the mixed sample was thoroughly stirred for 5-10 minutes. After a time interval, a firm curd was obtained. After that whey was drained and curd was washed in tap water for 5-10 minutes. Furthermore, grinding cheese was molded to remove water and spreadable cheese was packed in an airtight glass container [10].



Figure 2: Show preparation of spreadable cheese.

Development of Fortified cheese using mushroom powder

Mushroom powder (45 gram), salt (NaCl), and black pepper were incorporated into prepared cheese (200 gram) for the development of (260 gram) fortified cheese.

Nutritional composition of fortified cheese and mushroom powder

The approximate composition of the fortified cheese and mushroom powder was determined by a standard analytical method. The total protein contents were determined by the Kjeldahal method of [11]. The total fat was estimated by Ether Extraction Method [12]. Ranganna method was used for the estimation of moisture and Ash content [13].

SEM Technique

Scanning electron microscope (SEM) is a method for imaging the morphology and microstructure of the materials. And EDS (Energy dispersive x-ray spectroscopy) is used to provide element identification [14]. The microstructure of spreadable cheese was analyzed by scanning electron microscopy using SEM (Model: JSM6490LV, JEOL, JAPAN). Samples were mounted on aluminum stub using double-sided carbon tape, then the sample was coated using a sputter coater (JEOL JFC-1600) auto fine coater.

XRD (X-Ray Diffraction)

X-ray diffraction analysis (XRD) is a technique for the crystallographic structure and amorphous structure of a material. XRD technique is using Model: D8 Advance Eco and Make: Bruker, Germany. The sample is prepared for X-ray diffraction by grinding to powder form/tale (< 0.062mm). Then place the amount of sample in the center of the sample holder and spread the sample to a thin layer then put in a desiccator and transfer to sample holder for XRD analysis. After that loading the sample and then scanning.

Sensory analysis

The developed frofified cheese was analyzed for five mainly sensory characteristics (appearance, taste, texture, aroma, and overall acceptability). Sensory evaluation was performed by a panel of 10 trained panellists from the Food Science and Technology Laboratory, Babasaheb Bhimrao Ambedkar University Lucknow, U.P, India. All the panel members are medically fit for sensory analysis. Sensory evaluation was performed at normal temperature. 10-point Hedonic rating scale (1 = dislike extremely, 2 =, 4 =, 6 =, 8 =, 10 = like extremely) was used for evaluating of the frofified cheese like the appearance, body and texture, aroma, taste and overall acceptability of the frofified cheese [15].

Results and Discussion

Nutritional analysis

Spreadable cheese is the best source of essential nutrients such as fat, protein, and vitamin. During the present study, it was analyzed that the nutritional value was affected by enrichment due to the addition of mushroom powder. These results from the previous study during the thesis work.

Cheese	T0 (Mushroom powder)	T1 (control)	T2 (fortified cheese)
Protein	10.98	22.45	29.08
Fat	2.88	28.9	32.22
Moisture	9.42	52.36	58.66
Ash	4.85	2.72	3.95

Table 1: Nutritional analysis of treatments.

- **Protein:** The data on protein content in mushroom powder was 10.98 (Table 1) and spreadable cheese addition with mushroom powder, control cheese varies T1 and T2 Treatment, where protein content of T1 was 22.45 and T2 protein was 29.08 while the protein content in mushroom powder (T0) was 10.98 was shown in table (3.1). therefore the difference between T1 and T2 was 6.63 which is increased protein content in fortified cheese(T2) that was higher than control cheese (T1).
- **Fat:** After the observation from the table (3.1), the amount of fat content in spreadable cheese was different treatment T1, T2. Where fat content T0 (2.88), T1 (28.9), T2 (32.22). Therefore the difference between T1 and T2 was (3.32) was rapidly increased and higher than the control cheese sample.
- **Moisture:** From the perusal data on moisture in spreadable cheese of different samples were present in the table (3.1). Where moisture content was T0 (9.42), T1 (52.36), and T2 (58.66). The difference between T1-T2 was (6.3).
- **Ash:** After the evaluation of ash content from a table (3.1), the ash content in control cheese sample T1 (2.72), fortified cheese T2 (3.95), and mushroom powder T0 (4.85). The difference between T1-T2 was (1.2) which is less than the control cheese sample (T1).

Analysis of the microstructure

SEM (Scanning electron microscope) was created to determine the relationship between the microstructure of samples and their composition. Figure 2 shows the pictures obtained for the cheese, fortified cheese, and mushroom powder. The SEM- image of mushroom powder presents Agglomerated structure and a highly branched-like structure. And spreadable cheese was compact supermolecule matrixes with little numbers of erratically spread fat globules were discovered on top of things cheese just like that privy by [16]. This sort of structure is formed for common cheese from milk and acidified. This result was consistent with fortified cheese product composition with high protein and moisture content [5].

The EDS graph spectra exhibit the purity of the material and the complete element composition of fortified.

Energy dispersive x-ray spectroscopy (EDS)

The present EDS figures and table shows different elements of composition present in control cheese, fortified cheese, and mushroom powder. Results shown in figure. attained from the EDS characterization indicate that the control cheese sample has an Oxygen content was 32.83%, carbon content was 66.33%, and calcium content was 0.08%. And Na, P, Cl, Ca, O, and C are elements found in

Figure 3: SEM images A is a controlled sample of cheese, B is a fortified sample of cheese, and C is a mushroom powder sample.

Figure 4: EDS image of A is a controlled cheese sample, B is a fortified cheese sample, C is a mushroom powder.

Control cheese			Fortified cheese			Mushroom powder		
Element	Weight%	Atomic%	Element	Weight%	Atomic%	Element	Weight%	Atomic%
C K	66.33	72.84	C K	64.77	72.84	OK	77.21	94.68
O K	32.83	27.84	O K	27.43	23.16	Mg K	0.52	0.42
Ca K	0.08	0.03	Na K	4.91	2.89	Cl K	1.65	0.92
Pt M	0.78	0.05	P K	0.30	0.13	K K	4.77	2.39
Totals	100.00		Cl K	2.49	0.95	Pt M	15.85	1.59
			Ca K	0.09	0.03			
			Totals	100.00		Totals	100.00	

Table 2: Elements composition of the sample.

fortified cheese, and O, Mg, Cl, K are elements found in mushroom powder.

XRD analysis

The nature of spreadable fortified cheese using the XRD pattern was amorphous with short-range ordering. The material was the very broad humped peak.

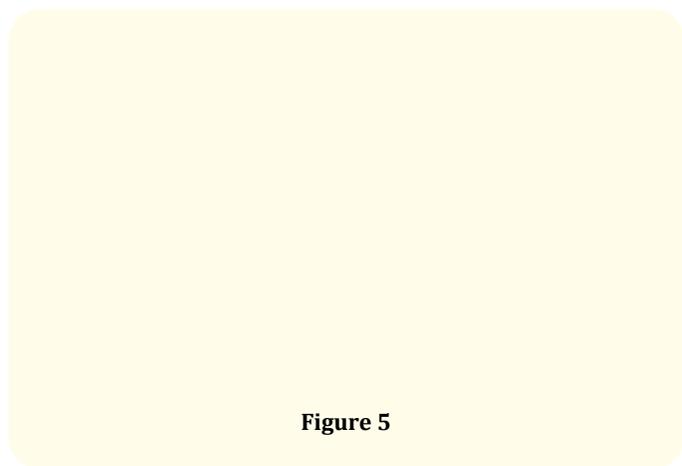


Figure 5

Sensory assessment

Sensory analysis was performed primarily to identify the fortified cheese with the highest acceptability. The sensory properties show a crucial factor that affects the person’s decision to purchase cheese, therefore, added ingredients mustn’t negatively affect the sensory properties [17]. The assessment by trained judges on samples of cheese was T1 (control cheese) and T2 (fortified cheese), considering the attributes of appearance, texture, flavour, aroma, and overall acceptance, square measure shown in figure 6. In this study, the color of the mushroom powder enriched cheese was observed significantly different from the control cheese sample (Table 3). Sensory analysis was performed primarily to identify the

fortified cheese with the highest acceptability. They scored nine points four out of ten in the overall acceptability of sample T2. Fortified cheese was most acceptable in terms of texture as compared with the control sample by the panellists. It was scored fortified cheese (8.5) which was closest to the control’s score (8.5) (Table 3). Taste is one of the main important factors of food for acceptability of people. In addition, the taste is a more powerful element than health-promoting aspects for product selection. Fortified cheese was most acceptable in terms of flavour as compared to control cheese sample by the panellists. It was scored fortified cheese (8.8) which was higher to control cheese scored (8.1) sample. Fortified cheese had scores ‘like very much’ means it is indicted that the product is had the highest overall acceptability at 9.4 (Table 3). The control sample was “like moderately” means It did not fall into the category of dislike means this product can be accept by the panellist.

Cheese Sample	Appearance	Texture	Flavor	Aroma	Overall acceptability
T1	8.1	8.5	8.1	8.2	8.9
T2	8.3	8.7	8.8	8.5	9.4

Table 3: Evaluation of sensory analysis.

An experimental product developed by incorporating mushroom powder.

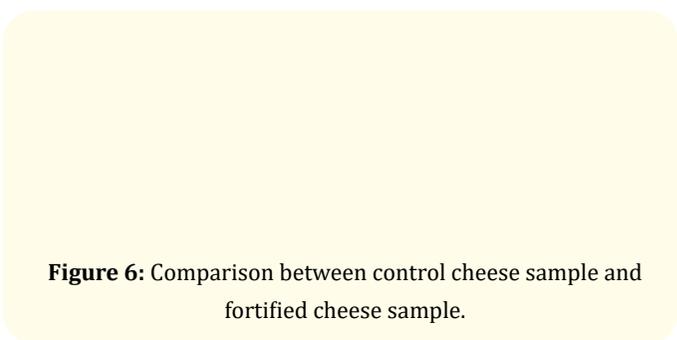


Figure 6: Comparison between control cheese sample and fortified cheese sample.

Conclusion

The experiment data was observed of the fortified cheese was higher nutritional value and higher nutrition properties of enrich the quality of spreadable cheese. In the experimental data of fortified cheese, Cheese was higher formulated with mushroom powder. Fortified cheese was prepared, studied, and stored. The spreadable cheese was modified to incorporate a mushroom powder result product with higher compositional, nutritional, and sensorial qualities. The sensorial evaluation Fortified cheese has been received positively and with reasonably high acceptability. These enriched products are healthy. The improvement of the nutritional value of fortified cheese is necessary due to people's demand for healthy and nutritious food.

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Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of the paper.

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