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Studies on different drying, canning and value addition techniques for mushrooms (*Calocybe Indica*)

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Drying characteristics and the quality of dried mushrooms were analyzed. *Calocybe indica* slices (5 mm) were dried in cross flow dryer, open sun dryer, solar dryer, through flow dryer, vibro dryer, vacuum dryer in the respective drying chambers at 65, 36, 55, 60, 55 and 45°C. Mushrooms were dried from about 84 to 3% moisture content (w.b) in about 8 h. Solar drier was cost effective and efficient in drying in the overall analysis. Potassium meta bisulphite (0.25 g/l) and 3% H_2O_2 and was proposed for washing mushrooms which supports storage up to six days with minimal contamination. Mushroom jam was made with different sources of pectin; however, jam made with natural pectin (guava) showed highest sensory score. Mushroom squash Formulation - III contains flavor enhancers such as amla and lemon extract.

Key words: *Calocybe indica,* drying, driers, mushroom, post harvest, value addition, jam, canning and squash.

INTRODUCTION

Generally, for long-term storage of mushrooms, canning and drying processes along with some value addition technology are employed. The quality of the preserved product is rarely comparable with that of fresh mushrooms, and these processes are not always suitable for all types of mushrooms.

Fresh mushrooms are highly perishable with short shelf life under ambient environment, temperature and humidity and their commercialization becomes difficult. Among the various techniques employed for preservation of mushrooms, drying seems to be an effective approach to extend shelf life and ensure distribution. Various drying techniques are employed to dry different food products. Each technique has its own advantages and limitations (Deka, 2000). Studies comparing traditional sun drying and other drying techniques show that the use of solar dryer leads to a considerable decline of the drying time and to a significant development of the product quality in terms of color, texture and taste.

Canning is the most common process used for preserving mushrooms. Preservation of mushrooms by canning has turn out to be considerably more specialized in recent years. Jam production was adopted as a preservation method to overcome the losses that occur in the mushroom cultivation. Standard formulations can be developed according to their end use, consumer fondness, market demand, food laws, buyer's specifications and economic utilization (Deka and Sethi, 2001). Mushroom squash is not quite popular as it does not have a greater variety of beverages. Preparation of nutritive ready-to-serve (RTS) beverages is considered to be a suitable and economic substitute for utilization of mushroom squash (Bala et al., 2009). Lack of technology of the processing of mushroom and inadequate information on the chemical properties increases the degree of losses.

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The aim of this work was to investigate the effect of different washing, drying and canning methods on quality of mushroom and to develop formulations for some value added mushroom products such as jam and squash.

EXPERIMENTALS

Determination of chemical for washing mushroom

Mushrooms were washed to increase the shelf life period with the chemicals such as citric acid, potassium meta bisulphite (KMS), hydrogen peroxide (H_2O_2) and chlorine. Parameters noted were color change, texture, storage time and taste.

The KMS was prepared at a range of 0.25 g/l, 1 g of citric acid was diluted with distilled water. Similarly H_2O_2 (3%) and chlorine of 20 ppm was used for washing. Washed mushrooms were observed for their shelf life for a period of six days. Total microbial count was measured using plate count method described in the FAO Manual (FAO, 1995).

Effect of different dryers on dehydration of mushrooms

Mushrooms were processed at optimal temperatures. Fully matured milky mushrooms were cut into 5 mm thick slices. No pre-treatment/blanching was done and the mushroom slices were dried from an initial moisture content of approximately 90% (w.b.) to the final moisture content of about 10% (d.b.) in cross flow dryer (65±1°C), open sun dryer (36±3°C), solar dryer (55±2°C), through flow dryer (60±1°C), vibro dryer (55±1°C) and vacuum dryer (45±1°C).

Estimation of dehydration time of mushrooms using various dryers

Mushroom sample was divided into six equal parts and were dried properly in dehydrators at temperatures indicated above. A sample from each dryer was removed every 30 min. The moisture content was measured by weighing the mushroom samples then placing them in a hot air oven at 80°C and reweighing the samples after they have completely dried.

Estimation of total drying time

The total drying time to reduce the moisture content of mushroom from approximately 86% (d.b.) to < 6% (d.b.) was estimated. Depending on the operating conditions of the dryers, the drying time varied from 4 h 45 min to 18 h.

Enumeration of microbial population from the dried mushroom by total plate count method

Microbial analyses were done by serially diluting the samples and the dilutions were pour plated at a dilution of 10^{-6}.

Estimation of microbial and sensory quality of canned mushrooms

Batch I, Fresh milky mushroom was selected and washed with clean water. The washed mushrooms were filled into cans, covered with various concentrations of brine solution containing citric acid and NaCl and pre heated at 85°C for 5-7 min, and then the cans were sealed immediately and sterilized at 116°C for 35 min, then cooled and stored at ambient temperature.

Batch II, mushroom was placed in cans containing various concentrations of sodium chloride and calcium ions. Similar canning procedure was performed. The microbial quality was analyzed with plate count technique.

Preparation of mushroom jam

The washed mushrooms were pulped with mortar and pestle; and the crude mixture pulp was sieved through an 80 nylon mesh.

Pulps from apple and banana were processed into fruit jams according to the FAO guideline (FAO, 1997). Along with that natural pectin (guava), synthetic pectin, sea weed were tested as different gelling agent. Guava pectin was extracted by boiling the guava pieces (one part with two parts of water) for 30 min. Mushroom pulp was 33-45 parts, along with mixture of fruits such as apple and banana were in 50% of the total mushroom for the preparation of jam. Total soluble solids (TSS) and total titratable acidity (TTA) were determined in the pulp before jam preparation to establish any additional requirement to meet the recommended acid to sugar ratio. After analyzing sugar ratio citric acid and sodium chloride were added to the mixture. The mixture was processed to the desired TSS of 69% and checked by using a hand refractometer (Hand refractometer 58 to 90° Brix). Finally, the jam was mixed with class II preservative sodium benzoate (100 ppm). Later, the hot jam was filled into sterilized glass bottles and left to cool and aluminum foiled. Then they were stored at room temperature (27 to 32°C). Storage stability of the prepared jams was assessed by following their changes in total soluble solids using refractometer, titratable acidity using AOAC standard method by titrating 10 ml of the pulps and juices against 0.1 M NaOH standard solution using phenolphthalein indicator (AOAC, 2000) and total microbial plate microbiological analysis was performed according to the FAO Manual (FAO, 1995).

Preparation of mushroom squash

Calocybe indica 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 crushed in screw type juice extractor machine for extraction of juice. Amla (Indian gooseberry) juice and lemon juice were added along with the extract. The juice was filtered through muslin cloth. A calculated quantity of potassium meta-bi-sulphite (750 ppm) was dissolved in a part of water according to the treatments and well mixed in the blended juice with the help of stirrer. Sugar syrup made with the addition of citric acid, sugar syrup and water was added to the extracts at different proportion. Squash was made by mixing the extract of *C.indica*, along with extracts of amla, lemon and sugar syrup in three different formulations. The squashes were diluted with purified RO water until it reached 52° brix in refractometer. The squashes were adjusted to have an acidity level of 0.16. The bottles containing squash were stored at room temperature (28 ± 8°C) for further storage studies and analyzed at 60 days intervals for six months.

Sensory analysis

The sensory quality was analyzed during the storage period such as taste, colour, texture, appearance and overall acceptance.

Table 1. Effects of wash on mushrooms by viable plate count method.

Surface washing agents	Period of storage - log CFU.ml^{-1}			
	0 Days	2 Days	4 Days	6 Days
Control-water	5.9	6.3	8.4	10.1
KMS – 0.25 g/L	4.3	4.7	5.6	7.84
1 g citric acid + 5 g NaCl	4.7	5.17	6.2	8.68
3% H_2O_2	3.9	4.29	5.14	7.19
20 ppm Chlorine	4.5	4.9	5.89	8.24

Table 2. Effects of dehydration by different dryers.

Dryer	Temperature (°C)	Moisture % (db)	Drying time (min)	Plate count log (afterdrying) CFU.ml^{-1}
Cross flow	65±1	5.64	285	3.14
Open Sun	36±3	11.5	1080	7.78
Solar	55±2	4.52	350	3.53
Through flow	60±1	4.31	325	3.72
Vibro	55±1	4.18	375	4.24
Vacuum	45±1	3.74	455	5.65

These qualities were estimated by a five member trained panel having age of 25 to 35 years. The panel consists of three females and two males who were trained to be familiar with sensory properties of fruit squash and jam. The sensory testing method was an acceptance test in which the sensory parameters were scored on a descriptive hedonial scale of 1-6. The sensory parameters investigated included the following: (i) taste, (ii) colour, (iii) texture, (iv) odour and (v) overall acceptance. Descriptions of each score were as follows: 5– like very much, 4– like slightly, 3– neither like nor dislike 2– dislike slightly and 1– dislike very much. Sensory tests were replicated thrice.

RESULTS AND DISCUSSION

Effects of mushroom washing on the shelf life of mushrooms

The mushrooms were washed with various surface sterilizing agents such as 1 g citric acid + 5 g NaCl, KMS - 0.25 g/L, 3% H_2O_2 and 20 ppm chlorine. Washed mushrooms were observed for their shelf life for 6 days period. Microbial loads were significantly reduced to 4.3 log CFU.ml^{-1} in mushrooms treated with potassium meta bisulphate (KMS) (Table 1). Overall, the microbiological results show that the H_2O_2 wash was more efficient in reducing bacteria counts. Previously conducted studies proposed 3% H_2O_2 as efficient in reducing bacterial counts (Ndabikunze et al., 2011). Our research results recommend KMS and H_2O_2 for washing mushrooms, after washing, the water was drain off completely which supports of storage up to six days with minimal contamination.

Effects of dehydration by different dryers on *C. indica*

The total drying time to reduce the moisture content of mushroom from approximately 84 (w.w) to about 3% (d.w.) is summarized in Table 2. Depending on the operating conditions, the drying time varied from 4 h 45 min to 18 h. It was observed that the total drying time decreased upon increasing the temperature for a given drying air velocity and batch size. The drying time also decreased upon increasing the drying air velocity for a given temperature and batch size. For a given drying air velocity and temperature, the total drying time was more for larger batch size, which was expected.

Percentage moisture was proportional to the amount of time spent in the dehydrator. As the amount of time in the dehydrator was increased, the percentage moisture decreased. The results show that mushrooms dried in solar dryer and vacuum dryer showed moisture content (4.52 and 3.74) and drying time (3.53 and 5.65), respectively.

Effect of temperature on microbiological growth in mushroom

The microbial quality of dried mushrooms is shown in Table 2. Open dried mushrooms had a significant higher number (7.78 log CFU.ml^{-1}) of microorganism than all other dehydrated mushrooms and took 18 h to get dried. Increased moisture content of the open dried mushroom was higher when compared to other dryers, which could

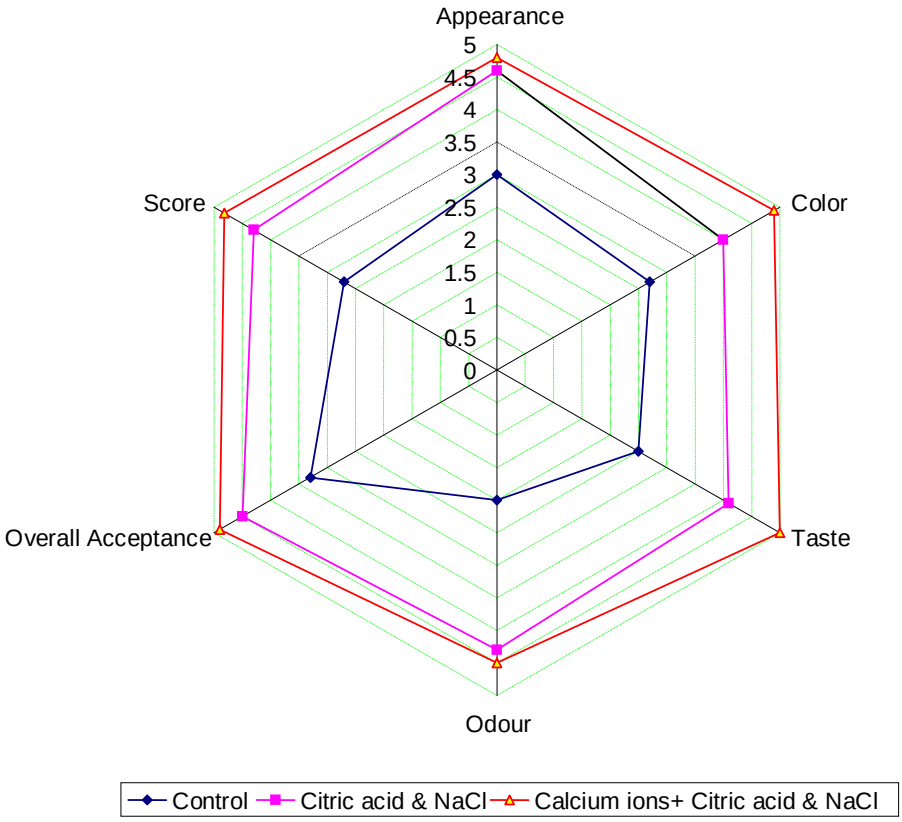

Figure 1. Sensory evaluation of canned mushrooms.

have influenced the microorganism on the dried mushrooms. Least colonies were observed in cross flow driers and solar dryer, 3.14 log and 3.53 log CFU.ml^{-1} respectively. The moisture content of mushroom reached 89.41 to 6.14% (wb) in 8 h of drying in the solar tunnel drier while it took 8 h of drying to bring down the moisture content in a similar sample to 15.0% in traditional sun drying method (Tiisekwa et al., 2002).

Effect of canning on microbial and sensory quality of mushroom

There were no colonies found in the mushrooms canned in brine containing citric acid and NaCl and exhausted, and similarly another batch of mushroom placed in cans containing sodium chloride and calcium ions were sampled frequently which showed no colonies on 4th, 8th and 12th storage months.

Microbiological analysis of glass containers, after 63-91 days, showed that canned recipes were in a condition of commercial sterility (Belitz and Grosch, 1999). Sensory analysis of canned mushroom results showed that the texture, color and taste were retained when the mushrooms were sterilized and canned with calcium ions with sodium chloride (Figure 1).

Effect of storage time on total acidity in mushroom jam

There were no variations in acidity observed during storage period in the present study. Similarly, previous study results pertaining to the titratable acidity revealed that acidity increased during storage. The mean value of acidity recorded were 0.6629 for storage period of 4th, 8th and storage months. The total soluble solids of mushroom jam were 68% during storage at the 12th month. For jam to be kept for a long time, it must have a TSS value of at least 65% (Martinez-carrera et al., 1998; Sapers et al., 1999), pH (3.0 to 3.5) and pectin (0.5%), which was the case with all formulated jams.

Effect of storage time on total microbiological growth in mushroom jam

The microbial quality of jams at different time of storage

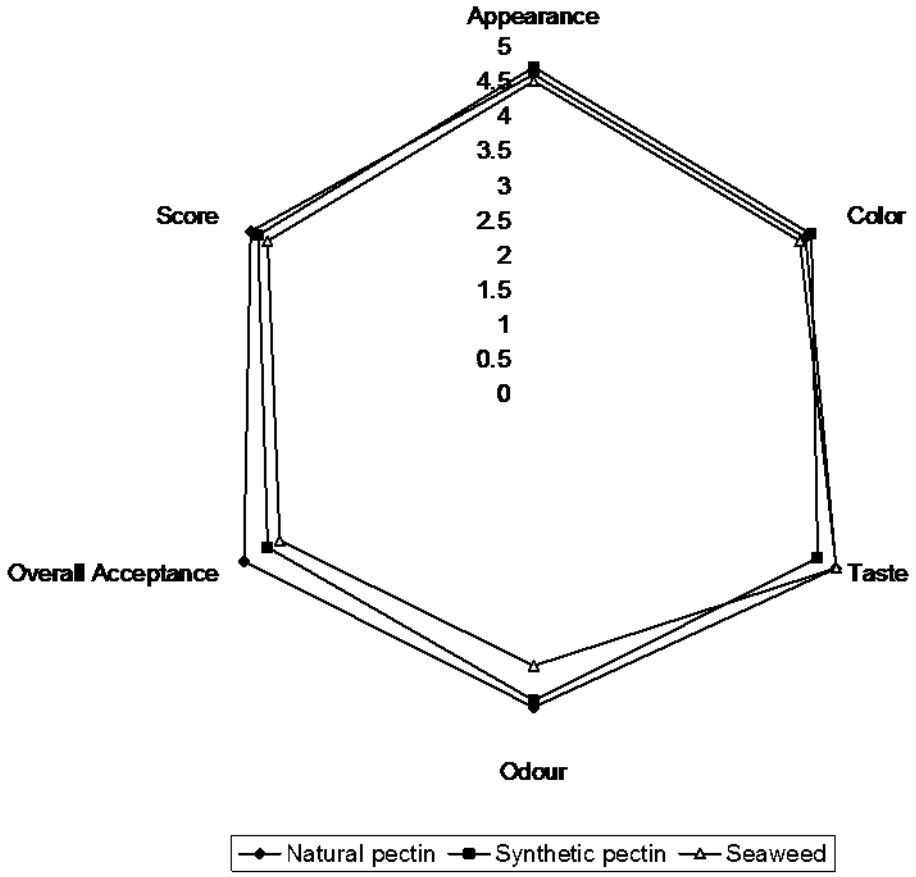

Figure 2. Sensory evaluation of mushrooms jam.

was not changed during its storage. In similar studies, Jam had 2 log CFU.ml^{-1} of microorganism initially. However, there was no significant microbial growth and no coliform growth in jam throughout the storage time. The results shows that jams formulated with additional pectin could be stored for six months at room temperature without spoilage (Deka and Sethi, 2001).

Sensory evaluation of mushroom jams

The sensory evaluation of the formulated jams is presented in Figure 2. In general, addition of natural pectin and synthetic pectin had significant effect on the taste of the jams produced. Jam prepared from sea weed alone had poor odor and a pleasant odor was produced by jam made of natural pectin. The appearance of jam was ranked significantly high among all other jams formulated with synthetic pectin. Fruit jams formulated with natural pectin was highly accepted and could be used as a substitute of the expensive commercial pectin in the preparation of indigenous fruit jams. Similar studies revealed that due to the high content of commercial pectin, the taste was rich (Saka et al., 2007; Manoj et al., 2009).

Enumeration of microbial population from mushroom squash

The data showed negligible count of microbial load (3 Log CFU.ml^{-1}), on mushroom squash. There was negligible growth of moulds and yeasts in lime – aonla and mango- pineapple spiced RTS beverages, which further reduced during storage due to inhibitory effect and antioxidative properties of spices (Bhardwaj and Mukherjee, 2011). Other studies reported that no bacterial growth was observed in the spiced mixed fruit juice, RTS beverages (Kirk and Sawyer, 1991).

Physico-chemical characteristics of squash

Effects on total soluble solids

The TSS (51%) observed in the mushroom squash did

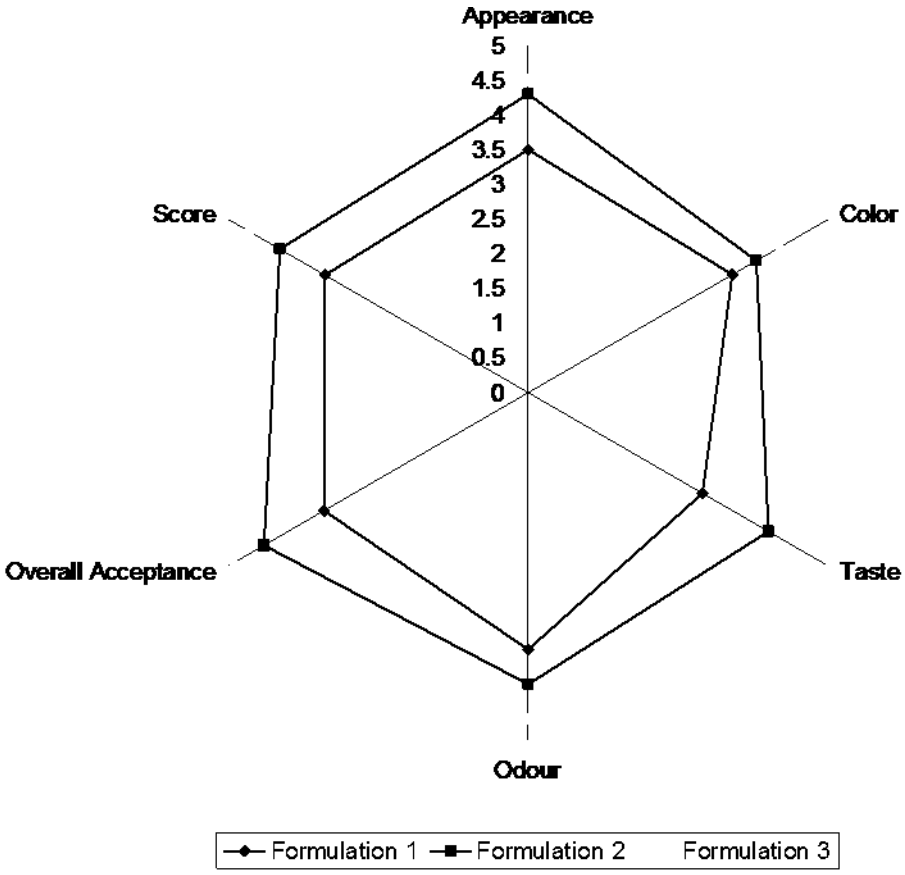

Figure 3. Sensory evaluation of mushrooms squash.

not change throughout its storage period in the current study. The TSS increased with gradual passage of storage time, which might be due to hydrolysis of polysaccharides into monosaccharide and oligosaccharides (Bala et al., 2009). Similar results were also reported in juice blends and found an increasing trend in total soluble solids during storage at ambient and low temperature in lime - aonla and mango-pineapple spiced RTS beverages (Bhardwaj and Mukherjee, 2011; Kirk and Sawyer, 1991).

Effects on acidity

There was a no significant decrease in titratable acidity content during storage. Previous studies on squashes observed that maximum acidity, 0.530% was recorded in the kinnow juice blended with ginger juice and Aonla juice. It was found that the acidity of the RTS beverage prepared from lime-aonla, mango-pineapple, guava-mango blends decreased with addition of spices with advancement of storage period up to six months under different storage conditions (Bhardwaj and Mukherjee, 2011).

Sensory evaluation of mushroom squash

In the present study, three formulations were evaluated for flavour, colour and organoleptic taste scores of squashes during the storage period (Figure 3). The colour, flavor and organoleptic taste of the squashes were found to be superior as for the formulation III when compared with squashes prepared from other formulations. In a similar study, the blend of kinnow juice (87%) + pomegranate juice (10%) + ginger juice (3%) recorded higher score for colour (7.27), flavour (7.43) and organoleptic taste (7.71) as compared to other blends at the end of storage (Bala et al., 2009).

Conclusions

Based on the study conducted, it clearly shows that washing will enhance the fresh mushroom life by removing the microbial load. Potassium meta bisulphite

(0.25 mg/L) and H_2O_2 (3%) showed the maximum removal of microorganisms results with 4.3 and 3.9 log CFU.ml^{-1}, respectively, at an acceptable concentration. On the basis of the above results it can be concluded that drying rate and quality was maximum for solar drier with moisture of 4.52% and 3.53 log CFU.ml^{-1}. When microbial analysis was done for canning there were no colonies observed for any of the sampling during its storage period of one year, similarly, the texture, taste and odor was maximum when the mushrooms were canned with calcium ions and sodium chloride. These results are in accordance with reports that total soluble solids and acidity did not change on storage. The overall acceptability of jam scored high (4.68) with the use of natural pectin. From the results of the present study, it may be concluded that formulation III is possible to satisfy consumer taste and preferences. These juice blends can be stored effectively for a period of six months at room temperature. It is suggested to extend the findings for future application or the main contribution in its applications.

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