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Study on Effect of Osmatic Dehydration on Quality of Butter Mushroom

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ABSTRACT

To enhance the quality of button mushrooms, osmotic dehydration was employed. The mushrooms underwent osmotic dehydration by immersion in brine solutions with concentrations of 5%, 10%, and 15% for 1 hour, followed by drying in a cabinet tray dryer at two temperatures: 50°C and 70°C.

The mushrooms dried in the cabinet tray dryer at 70°C, treated with a 15% NaCl solution, exhibited superior qualities. These mushrooms showcased the lowest moisture content (7.76%), shortest drying time (240 minutes), and minimal browning index (0.22). Additionally, they demonstrated higher dehydration ratio (12.3) and rehydration ratio (2.41), indicating enhanced preservation and reconstitution properties.

Keyword: button mushroom, osmotic dehydration, cabinet tray drying, pre-treatment.

CHAPTER-I

INTRODUCTION

Naturally, mushrooms are found in diverse agro-climatic conditions ranging from arid to evergreen forest conditions. Worldwide more than 3000 mushrooms have been identified as edible, of which 200 types are reported to have been produced under controlled conditions. However, not more than 60 varieties are being grown widely. There are about a dozen varieties which are cultivated on commercial scale. India is home to more than 300 varieties ofmushrooms found in the wild. The major mushroom varieties of commercial importance are Button (*Agaricus bisporus, A. bitorquis), Oyster–Dhingri (Pleurotus sp.),* Paddy Straw *(Volvariella sp.),* Shiitake *(Lentinula edodes),* Milky Mushroom *(Calocybe indica),* Winter mushroom *(Flammulina velutipes), Reishi (Ganoderma lucidum),* Black Ear *(Auricularia sp.)* etc. Morel *(Morchella esculanta)* is seasonally harvested from the wild in north Himalayan states. In India, three types, namely button, oyster and straw mushroom are extensively cultivated on commercial scale ***(Kumar et al. 2017)***.

Mushroom cultivation slowly spread to North western plains of India (seasonal crop during winter). In Rajasthan, production of mushroom started in 1980. Mushrooms are the healthfood of the world. Analysis of fresh button mushroom show that they contain 90 to 93% moisture, 28 to 42.5% crude protein, 8.3 to 16.2% crude fibre, 9.4 to 14.5% ash, 59.4 % carbohydrates and 3.1% fat. Among the minerals 71 mg calcium, 912 mg phosphorous, 106 mg sodium, 8.8 mg iron and 2850 mg potassium (per 100 g dry weight basis) are present. Among the vitamins 8.9 mg thiamine (B1), 3.7 mg riboflavin (B2), 26.5 mg ascorbic acid (C) and 42.5 mg niacin (B3) are also available on 100 g dry weight basis ***(Goyal et al. 2015)***.

Button mushroom (*Agaricus bisporus*) is the most popular variety, fetches high price, still dominating the Indian and International market. It contributes about 90% of total country's production as against its global share of about 40% **(*Chang and Miles, 2004)***. The method of cultivation of mushroom was recorded as early as 300 BC and their international cultivation was started as early as 600 AD in China. However, commercial production of white button mushroom was initiated in the hilly regions of the country (17- 18°C) like Chail (Himachal Pradesh) Kashmir and Ooty (Tamil Nadu).

Production and consumption of button mushroom have registered tremendous increase in the recent past ***(Singh et al. 2008)***. Mushrooms are liked for their delicious flavour, low calorific value and high protein contents, vitamins of B-group and minerals. Mushroom contains 20– 40% proteins on a dry weight basis and no cholesterol, and is almost fat free **(*Walde et al. 2006)***. Mushrooms are a good source of non-starchy carbohydrates, dietary fiber, protein, mineral and vitamins ***(Kulshreshtha et al. 2009)***. Mushrooms are a good source of many compounds, including phenolics, vitamins (thiamine, vitamin C, riboflavin, and tocopherols) and flavonoids ***(Nile and Park, 2014*)**. These components are known for their antioxidant potential, however, are susceptible to processing techniques, particularly heat processing.Mushrooms are a seasonal and highly perishable crop and contain about 90% (w.b) moisture. After harvesting, moisture loss, shrinkage and rapid spoilage in terms of colour and texture takes place. The shelf life of mushroom is only about 2 to 5 days depending upon the variety. There are many methods for preservation and enhancement of shelf life of mushrooms. The most common processes include canning, freezing and drying. Although canning is widely used on a commercial scale, it is quite expensive ***(Kulshreshtha et al. 2009)***. It is reported that drying is a comparatively cheap method ***(Rama and Jacob John 2000)*** and dried mushrooms, packed in airtight containers can have a shelf life of above one year ***(Bano et al. 1992)***. The factors that affect drying rate are temperature, thickness of mushroom, method of drying and moisture diffusivity ***(Yapar et al. 1990)***. Production and consumption of mushrooms is increasing due to their medicinal and nutritional value ***(Rai and Arumuganathan, 2003)***.

In India, white button mushroom (*Agaricus bisporus)*, oyster mushroom (*Pleurotus sajor- caju)* and the paddy straw mushroom (*Volveriella volvaceae)* are commercially grown of which white button mushrooms contributes 90%, to the total production. The world's largest button mushroom growing unit is located in Punjab, India ***(Mehta et al., 2011)***. Punjab alone produces about 32% of the total production in India. The white button mushrooms are low in calorie, as the carbohydrates are stored as glycogen: chitin, hemicellulose instead of starch ***(Matilla et al. 2001)***. But due to high moisture content, they start deteriorating immediately within a day after harvest due to microbial, enzymatic and chemical reactions. Thus, it is very important to evolve a suitable method of preservation for increasing the shelf-life besides maintaining this quality. It can be achieved by some type of processing e.g. heating, dehydration. To save the crop from post-harvest losses, it has to be preserved in one or the other form and drying is one of the methods of preservation. Drying is the easiest means to increase the longevity of high moisture products ***(Shukla and Singh, 2007)***. On the other hand, mushrooms are very sensitive to temperature, therefore choosing a proper method of drying is a very important decision ***(Rezagah et al. 2010)***. The six major constituents of mushrooms are water, proteins, carbohydrates, fiber, fat, and ash along with minerals and essential amino acids ***(Heleno et al. 2010)***.

Osmotic dehydration is used for partial removal of water from materials such as fruits and vegetables by immersing in aqueous solutions of high osmotic pressure such as sugar and salts ***(Pandharipande et al. 2012)***. It is used as a pre-treatment before hot – air drying of mushrooms because it has the advantage of improving nutritional, sensorial and functional aspects of foods without changing its colour, texture and aroma. Besides, the osmotic dehydration minimizes the thermal damage to colour and flavour prevents enzymatic browning ***(Mehta et al. 2013)***. Due to their unique and subtle flavour, mushrooms have been used as food and food flavouring material in soups for centuries ***(Tulek, 2011)***. The dehydrated product offer, apart from increased shelf-life, the advantage of decreased mass and volume which have the potential for savings in the cost of packaging, handling, storage and transportation of the product. The methods of drying as well as physiological changes that occur in foods during drying and it effects the quality of the dehydrated products. Conventional air drying is one of the most frequently used methods for mushroom dehydration, which involves thermal and/or chemical pre-treatment and drying at temperature maintained between 50^0C and 70^0C. Due to long drying time and overheating of surface during hot air drying, the problems of darkening in colour, loss in flavour and decrease in rehydration ability occur ***(Giri and Prasad, 2012)***. It may be mentioned that pre-treatments of mushrooms before drying in one form or other viz, washing in water, potassium metabisulphite (KMS), sugar, salt either alone or in combination help in checking enzymatic browning, stabilizing colour, enhancing flavour retention and maintaining textural properties ***(Walde et al. 2006)***. Thus, dehydration combined with some pre-treatments appear to be a cost effective method of preservation for Indian conditions as dehydrated mushrooms are easy to transport as compared to the canned, pickled and frozen products.

OBJECTIVES

1. Evaluate the drying characteristics of osmotically pre-treated dried button mushroom slices.
2. Determine the nutritional characteristics of osmotically pre-treated dried button mushroom slices.
3. Study the organoleptic attributes of dried button mushroom slices subjected to osmotic pre-treatment

CHAPTER-II

REVIEW OF LITERATURE

The literature pertaining to different aspects of the present study has been reviewed under the following headings and subheadings.

2.1 Drying characteristics

Krokida *et.al* (2003) Investigated the effect of air conditions (air temperature, air humidity and air velocity) and characteristic sample size on drying kinetics of various plant materials (potato, carrot, pepper, garlic, mushroom, onion, leek, pea, corn, celery, pumpkin, tomato) was examined during air drying. A first-order reaction kinetics model was used, in which the drying constant is function of the process variables, while the equilibrium moisture content of dried products within the range of 0.10–0.90 water activity at two temperatures (30 and 70ºC) was fitted to GAB equation. The parameters of the model considered were found to be greatly affected by the air conditions and sample size during drying. In particular the temperature increment increases the drying constant and decreases the equilibrium moisture content of the dehydrated products.

Shukla *et.al* (2007) studied that osmo-convective drying of cauliflower, mushroom and green pea was carried out respectively in appropriate concentrated solution of sugar–salt, salt, and sugar–salt plus MgHCO3 in water. The reduction in moisture content during osmotic dehydration process of 5 hwas 40–60% wb. Further drying of the osmosed products wascarried out in a tray dryer maintained at 60°C to moisture content of 6–8% wb. Quality parameters like texture, moisture content, colour, hydration as well as rehydration ratios, and microbiological loads were evaluated and found acceptance to a satisfactory level.

Kulshreshtha *et.al* (2009) Mention that Fluidized bed drying of mushroom was undertakento study the drying characteristics and quality of the dried mushrooms. Drying was done at drying air temperatures of 50, 70 and 90°C and air velocities of 1.71 and 2.13 m/s. Two batch sizes, namely, 0.5 kg and 1 kg of sliced milky mushrooms were dried. Drying characteristics and the quality of dried mushrooms were analysed. The results indicated that the drying time decreased only marginally with increase in air velocity. Drying air temperature of 50°C was better as it resulted in a dried product having better rehydration characteristics, lesser shrinkage and lighter colour. Highest energy efficiency (79.74%) was observed while drying a batch size of 1 kg at a drying air temperature of 50°C, using an air velocity of 1.7 m/s.

Patil and Kubde (2011) suggested that Dehydration of button mushrooms (*Agaricus bisporus*) were carried out with various pre-treatments like blanching, socking in different combination of sodium metabisulphite, potassium metabisulphite, citric acid, sugar and sodium chloride in fluidized bed dryer. The dehydration experiments were carried out at

different temperature of 40, 45, 50 and 55°C. The moisture loss data and drying characteristics

such as drying rate, diffusivity, moisture ratio, during the drying process were determined. The qualities of dehydrated mushroom slices were evaluated on the basis of colour, appearance, rehydration ratio and veil opening by sensory evolution. The diffusion coefficient evaluated were 1.03 x 10-8 m2/s to 9.64 x 10-9 m2/s in tray and fluidized bed dryer, respectively. The sample treated with combination of potassium metabisulphite, citric acid,

sugar and NaCl at 55°C temperature were better accepted by consumer panel. The minimum and maximum rehydration ratio was found 1.90 to 2.61, respectively.

Giri and Prasad (2012) described that button mushroom (*Agaricus bisporus*) slices as well as whole mushrooms were dried by microwave vacuum drying technique to a moisture contentof around 6 % (d.b.). The dehydrated mushrooms were compared with hot-air dried productson the basis of different quality attributes such as colour, texture, rehydration ratio and sensoryscore. Statistical analysis of data revealed significant difference among the drying methods for all the attributes at $p \leq 0.05$. Microwave-vacuum dried mushrooms had significantly higher rehydration potential, lower density, better colour and softer texture than those obtained by air drying. The microwave-vacuum dried mushrooms were rated much better than air dried products by a sensory panel in terms of appearance, colour and overall acceptability**.**

Nimmanpipug *et.al* (2013) subjected to hot air drying (70°C) and microwave vacuum drying (1200 W and 13.3 kPa) of osmotically dehydrated papaya. Osmotic dehydration was carried out in sucrose solution (65 % (w/w)) at 40±2 °C for 1 – 4 h. The ratio of papaya to the solutionwas 1:5. In the hot air drying, an increase in osmotic dehydration time from 1 to 4 h decreased hardness, lightness (L* value) and chroma (C* value) of papaya significantly ($P<0.05$).In the microwave vacuum drying, a similar trend of hardness reduction was observed when the osmotic dehydration time was increased. However, the microwave vacuum dried papaya had lower hardness and chroma than the hot air dried samples. Hue angle (°h) of the microwave vacuum dried papaya was in the range of 48.55 – 50.32 whereas that of the hot air dried samples was in the range of 0.83 – 0.91. Regarding the scanning electronic micrograph, increasing osmotic dehydration time could reduce the shrinkage of the hot air dried papaya and reduce the degree of damage in the microwave vacuum dried papaya. Comparing between both drying conditions, the microwave vacuum drying yielded the fine and porous structure, whereas, the hot air drying yielded the dense structure. Therefore, rehydration rate constant of the microwave vacuum dried papaya was significantly higher than that of the hot air dried samples ($P<0.05$).

Shete *et.al* (2015) conducted that the freshly harvested green peas procured from local market were cleaned and sorted. The average moisture content of the fresh green peas was found 70 to 75% on wet basis. Three different samples of green peas with respect to pre-treatments *viz.*, raw, blanched and blanched after pricking were taken for drying experiment. A laboratory model tray dryer was used for drying green peas with different levels of drying air temperatures (50, 60, 70ºC). Drying time, moisture reduction was calculated later with the help of observed data during tray drying. The dried green pea samples were taken for quality evaluation by sensory method, rehydration of final product was also carried out. Survey results underlined the need of technological intervention at various stages of post-harvest processing of green peas in this region. Drying of blanched green peas after pricking at 50°C drying air temperature resulted in shorter drying time to produce best quality dried product as compared to raw and blanched green peas. The dried green peas with final moisture content 7.52% on wet basis showed best rehydration characteristics to yield good quality rehydrated peas which could be preserved and used during off-season.

Kortei *et.al* (2016) proposed that Oyster mushroom slices *(Pleurotus ostreatus)* were exposed to ɣ-radiation as a pre-treatment and solar dried to investigate the influence of irradiation on drying kinetics. Processing conditions included exposure of mushrooms to 0 kGy (control),

0.5 kGy, 1.0 kGy, 1.5 kGy and 2.0 kGy of ɣ-radiation at a dose rate of 1.7 kGy/h and drying at amean temperature of 53.2±6.4°C. Experimental drying data were fitted to 5 thin layer drying models by non-linear regression. Irradiation was observed to enhance the drying rate of mushroom slices, with higher doses causing faster moisture removal. Drying characteristics of slices exposed to lower dosages were best described by Page's model (R2=0.9878, 0.9967, 0.9925 correspondingly for "control" (0.0 kGy), 0.5 and 1.0 kGy while the Diffusion model best ft the data for those exposed to higher doses of radiation (R2=0.9938, 0.9890 for 1.5 and

2.0 kGy respectively). Deff ranged from 1.88 to 2.44 x 10-08 and increase from "control", 0.5 kGy, 1.0 kGy, 1.5 kGy to 2.0 kGy. Irradiation of mushrooms as a pre-treatment for drying increases moisture diffusivity and drying rate with higher doses having the most effect.

Raj *et.al* (2016) Drying is used to increase the shelf life of mushroom by reducing moisture. Drying experiments were conducted using Rotatable Central Composite Design (RCCD) technique based on Response Surface Methodology (RSM). The slice thickness and air temperature were taken as independent variables. The dependent variables taken were drying time (Td), rehydration ratio (RR) and visual colour (VC). Blanched mushroom samples of slice thickness (6-14 mm) were dehydrated in a tray dryer at air temperature range of 50-70 ºC. The optimum values of drying air temperature and slice thickness were found to be 67 ºC and 11.78 mm respectively at desirability value of 0.654. The optimized drying conditions can be utilized in mushroom dehydration industry.

Supakarn *et.al* (2018) Determine the equilibrium moisture content of Shiitake mushrooms under vacuum conditions by using a vacuum heat-pump dryer. The mushrooms were dried at apressure of 0.2 bar and temperatures of 50, 55, and 60°C. A saturated salt solution was used to control the relative humidity within 10-75%. This study found that vacuum drying tended to increase the equilibrium moisture content of the mushrooms and the relative humidity as the drying temperature decreased. Of the correlations proposed by Oswin, Guggenheim- Anderson-de Boer (GAB), Peleg, modified Oswin, and modified GAB, the functional form of Peleg was the best ft (R2 of 0.99). The moisture content of the mushrooms, as measured during drying, were used with the equilibrium moisture content values obtained from the proposed equations to determine the moisture ratios of the mushrooms at different drying times. Among nine well-known correlations, the functional form of the thin layer model proposed by Midilli best predicted the drying of Shiitake mushrooms under vacuum.

Bashir *et.al* (2019) evaluate the effects of different drying methods viz., sun, solar, oven (40

°C), microwave (300 W), freeze (-60 °C) and osmotic drying (14% salt solution followed by drying at 40 °C) on functional properties and sensory attributes of oyster mushroom. Significant differences in functional parameters (browning index, rehydration ratio, water solubility index and bulk density) and sensory attributes (appearance, aroma, texture and overall acceptability) were observed in response to different drying techniques. The least browning index of 0.22 was reported for freeze dried mushroom while as microwave dried oyster mushroom recorded highest browning index of 0.62. The study concluded freeze dryingas most suitable method of preserving mushroom with rehydration ratio, water solubility index, bulk density and overall acceptability value of 5.21, 1.91 per cent, 0.31 g per ml and 8.09 respectively.

Pre -treatments

Muyanja *et.al* (2012) determine the effects of pre-treatments and drying methods on the chemical composition and sensory characteristics of oyster mushrooms (*Pluerotus oestreatus*). Blanching had no significant (P = 0.10) effect on protein content but resulted in decreases in ash and increases in the carbohydrate content. Brining decreased protein, moisture content and increased ash content. The drying methods had no significant (P = 0.06) effect on the carbohydrate content. The treatments did not significantly affect the iron and zinc content of mushrooms. No significant difference in taste (P = 0.37) and flavour (P = 0.10) of the prepared soups was observed. Soups prepared from sun-dried powders had the highest overall acceptability scores. Blanching maintained the colour of mushrooms and combined withbrining for 60 min could be used to produce dried oyster mushrooms of acceptable quality.

Hosseini *et.al* (2014) reported increase the hold time and quality specifications, different pre- treatments including osmotic (NaCl2 with a 10% density ratio), chemical (metabisulfite potassium with concentration 0/5% density ratio), ultrasound (with a frequency of 28 ±0/5 (KHZ)), and microwave (with power 360 watt) were applied. These pre-treatments were dried through the hot air method. Osmotic, chemical, and ultrasound pre-treatments were used for 2 hrs 30 minutes and 30 minutes, respectively at ambient temperature, while the microwave was employed for 4 minutes. Then effect of various pre-treatments on the dried button mushrooms.Quality indexes such as texture, colour, and rehydration ratio was investigated.

Gupta *et.al* (2015) investigated that Osmotic dehydration of button mushrooms (*Agaricus bisporus*) slices carried out done by dipping them in brine of different concentrations of salt (10%, 20% and 30%), mass ratios (1/10 and 1/25 w/w) solution at a temperature of 60°C, and duration of 30 minutes. With respect to water loss (WL) and salt gain (SG), with the increase in concentration of salt, the water loss increased and the solid gain decreased. The quality of dehydrated slices were evaluated on the basis of moisture per cent, non-enzymatic browning, rehydration ratio and colour values. The lowest moisture content (6.3%) and non-enzymatic browning (0.37) and highest rehydration ratio of 2.68 respectively was observed in treatment T6 (containing salt 30g and mushroom to solution ratio of 1:25) was the best.

Kumar *et.al* (2017) concluded that White button mushroom (Agaricus bisporus) was subjected to osmotic dehydration at different concentrations of common salt (sodium chloride)
i.e. 10, 15, 20 and 25% and sugar solution i.e. 50, 60 and 70℃ and dried in hot air oven at 55
± 2 °C. There were about 31.2, 29.4, 27.2 and 24.4% reduction in weight with 10, 15, 20 and
25% salt solutions and 35.4, 38.3 and 38.8% with 50, 60 and 70°B sugar solution respectively. It took about 240, 220, 200 and 180 minutes to dry samples after osmotic treatment with 10, 15, 20 and 25% salt concentration and 240, 220 and 220 minutes with 50, 60 and 70°C sugar solution respectively. The untreated samples took about 340 minutes for complete drying. The colour was brighter for samples dried after OT with 25% salt and 70℃ sugar concentrations having lowest optical density (OD) values. The dried products were packed in 200 gauge polypropylene bags and stored at ambient condition for one year. The chemical, microbial and organoleptic changes were monitored for one year. Storage study showed that there was marginal increase in moisture content and decrease in organoleptic quality of osmo-air dried (OAD) mushroom slices. The samples dried after osmosis with 25% salt and 70°C sugar concentrations were found microbiologically safe and organoleptically acceptable up to one year of storage at ambient condition.

Keerthana and Srijaya (2018) subjected that the post-harvest management of fruits and vegetables is the major concern of most of the Food Processing Industries. To satisfy the growing market demand for commodities in a fresh like state, minimal processing such as osmotic dehydration is being extensively used. Osmotic dehydration, a less energy intensive process when compared to other drying techniques, helps to improve the nutritional and sensory attributes of food products, besides extending the shelf life. It is a versatile process for the infusion of bioactive compounds to produce functional foods which increase commercial market opportunities. Recently, the combination of osmotic dehydration with other non- thermal processes has gained much importance. High pressure and pulsed electric field treatments combined with osmotic dehydration have shown improved dehydration rates in the production of intermediate moisture products with high quality characteristics. Ultrasound treatment during osmotic dehydration resulted severe changes in cell structure. Vacuum applied prior to osmotic dehydration improved the porous structure of the food material, which enhances the mass transfer. Osmo dehydro-freezing, a novel technology can develop products with increased textural and quality characteristics with prolonged shelf life. Furthermore, the understanding of mass transfer mechanism during osmotic dehydration plays an important role in devising novel applications of this technique in food processing.

Champawat *et.al* (2019) assessed Osmotic dehydration of garlic cloves was done by dipping the cloves in 20, 25 and 30°Bx salt solutions at 30, 40 and 50℃ temperatures for 1.5 h. The effect of process parameters during osmotic dehydration such as duration of osmosis, concentration and temperature of salt solution on mass reduction, water loss and salt gain werestudied. It was found that the mass reduction, water loss and salt gain increased with increase of temperature and salt concentration. The mass reduction, water loss and salt gain after osmotic dehydration was found to be in the range of 2.83 to 8.36 %, 8.26 to 15.11 % and 5.43 and 6.47 %, respectively, corresponding to experiments at low level (20°Bx, 30 ºC after

1.5 h) and high level (30°Bx, 50ºC after 1.5 h).

Nutritional characteristics

Ngabo *et.al* (2016) observed that Mushrooms make parts of foodstuffs very perishable. With the aim of extending their shelf life, the drying is recommended. In this work, we used two modes of drying: the freeze-drying and the solar drying. After drying, samples were packaged in some newspaper paper and stored during 4 months at room temperature. Some small modifications were observed in the parameters studied before drying and after storage. The pHpasses from 6.5 to 6.2, the nitrogen of 0.067 mg at 0.057 mg, the phosphorus concentration decrease of 224 mg at 182.2 mg, the potassium did not change 0.6 mol, the proteins rate decrease 0,419 % at 0,338 % and the concentration of vitamin C decrease of 9.25 mol at 8.75 mol.

Tolera *et al* (2017) evaluated the effects of different levels of osmotic pre-treatments prior to drying and different drying methods on nutritional quality of dried mushroom slices. The experiment consisted of sun, solar, and oven drying after dipping the slices in salt solutions of5 and 10% concentrations for 50 minutes, the control being untreated mushroom sample. Significant differences in proximate composition were observed between the fresh and dried mushroom samples. The average mean value of crude protein, crude fat, crude fiber, ash, and carbohydrates of the fresh mushroom samples were 28.85, 2.47, 12.87, 9.76 and 48.16% as compared to 25.91, 2.18, 10.41, 10.91 and 42.14% for dried samples. Oven drying resulted in higher content of ash (11.06%) and carbohydrates (43.64%) and lower contents of crude protein (24.99%), crude fat (2.12%), and crude fiber (10.21%). The osmotic pre-treatments significantly affected the composition of the dried mushroom samples. As salt concentration increased from 0 to 5 and 10%, the protein content reduced from 26.78 to 25.99 and 24. 95%, the fat reduced from 2.42 to 2.19 and 1.94, and fiber from 12.82 to 9.41 and 9.01%, respectively. Contrarily, the ash increased from 9.75 to 12.20%, and the carbohydrate from 38.16 to 43.08 and 45.18%, respectively.

Owaid *et. al* (2017) stated that white button mushroom (*Agaricus bisporus*), Higher Basidiomycota, is a very important nutritional and medicinal species which is used for recycling agro wastes including wheat straw, reed plant wastes, waste paper, oat straw, waste tea leaves, some water plants and others. *A. bisporus* has many usages in human dietary and pharmaceutical fields due to its composition of essential amino acids, fatty acids,carbohydrates, low calories, crude fibres, trace elements and vitamins. Recently synthesized nanoparticles from *A. bisporus* were used to treat cancer, viral, bacterial and fungal diseases. The goal of this review is to highlight recent data about recycling wastes for *Agaricus* production and applications of *A. bisporus* as a reducing agent in the biosynthesis of silver nanoparticles. Organically produced foods are currently highly desirable, but it can also be used for eco-friendly biosynthesis of nanoparticles.

Mehta *et. al* (2017) subjected that consumption of food is directly related to the quality. Quality commonly thought of as a degree of excellence, is one of the major positioning tool of the producer for marketability and for consumers satisfaction. The input parameters during convective drying of osmotically dehydrated mushroom sample were optimized to 65oCdrying air temperature and 2.0 m/s air velocity for better response. The rehydration ratio of the osmo-convectively dried mushroom samples at optimized condition was in the range of 2.35to 2.82. Amino acid presence of osmo-convective dehydrated mushroom products were found maximum compared to convectively dried product (without osmo). Bacterial count and fungal count of osmo convectively dehydrated (optimized conditions) and convectively dehydrated mushroom samples were within permissible limit even in fresh samples. But, yeast and mould count in both osmo-convectively and convectively dehydrated products were nil. Osmoic convectively dried mushroom product at optimized input parameters was highly appreciated by the consumers than convectively dried product (without osmo).

Sharma *et.al* (2017) found that global mushroom industry has expanded very rapidly in the last two decades by the addition of newer types of mushrooms for commercial cultivation. However, mushroom as a vegetable is yet to find regular place among the Indian consumers. Despite of favourable agro-climate, abundance of agro wastes, relatively low-cost labour and a rich fungal biodiversity, India has witnessed a lukewarm response in its growth. At present, the total mushroom production in India is approximately 0.13 million tons. From 2010-2017, the mushroom industry in India has registered an average growth rate of 4.3% per annum. Out of the total mushroom produced, white button mushroom share is 73% followed by oyster mushroom (16%), paddy straw mushroom (7%) and milky mushroom (3%). Compared to othervegetables; per capita consumption of mushrooms in India is meagre and data indicates it is less than 100 grams per year. In the year 2016-2017, Indian mushroom industry generated revenue of Rs. 7282.26 lacs by exporting 1054 quintals of white button mushroom in canned and frozen form. By considering the production statistics, the spawn demand in India isestimated about 8000-10000 tons per annum. Majority of this commercial spawn to the growers is being supplied by the private units and the contribution of public sector organizations in spawn supply was limited to 10% only. In this article we made an attempt to analyse the current scenario of the mushroom industry with the assistance of AICRP network centres located across the country and discussed the opportunities and challenges for development of mushroom entrepreneurship in India.

Sharma and Bhat (2018) stated that mushroom slices were subjected to different pre- treatments (0.1% KMS, 0.2% KMS, 1% CaCl2, 2% CaCl2, 0.5% glycerol, 1% glycerol) for 15 minutes and then dried in cabinet tray dryer at 500C with a purpose to enhance the quality and for improved drying. Mushrooms pre-treated with 1% glycerol were best on the basis of lowest moisture content (8.30%), water activity (0.44), browning index (0.04), microbial count(1.32 c.f.u/g) and highest dehydration ratio (9.84), rehydration ratio (3.85), L* value (65.08) and crude fat (1.88%). Also, on the basis of organoleptic acceptability, T7 (1% Glycerol) was recorded as the best pre-treatment for maintaining the quality of mushrooms.

Farooq *et.al* (2018) explained global level many species of eatable mushrooms have been used for diet and medication purposes. In addition to its dietetic value mushroom have many medicinal importance because mushroom is used against several viral, bacterial and cancer diseases. Mushroom powder also used to reduce blood pressure and increase resistance of person against many diseases. Keeping in perspective the position of dietary and medicinal values of mushroom in this research mushroom powder was added into muffins to improve nutritious and dietetic status of muffin. To achieve desired objective mushroom powder was mixed with wheat flour to improve sensory attributes of muffins. The proximate analysis of mushroom based powder and wheat flour was also performed. After this loaf weight and volume, structural examination, sensual attributes of muffin was also performed. The effect of mushroom powder on moisture, crude protein crude fat and nitrogen free extract of muffin were non-significant and effect on ash and crude fiber were significant when 0%, 10%, 20%, 30% and 40% mushroom powder based muffin were prepared.

The effect of mushroom powder supplementations on loaf weight of muffin was significant and resulted in gradual decrease. However, the effect on loaf volume of muffins was non significant. The effects of mushroom powder on texture and colour value of muffin were highly significant. The results of sensory evaluation showed that muffin prepared with 10% mushroom powder have high sensory score while muffins prepared with 40% mushroom powder had very low sensory score.

CHAPTER-III
MATERIALS AND METHODS

3.1 Procurement of raw material:

Button Mushroom (*Agaricus bisporous*) were purchased from local market.

3.1.2 Equipment's to use for mushroom drying:

Cabinet tray dryer

Electronic weighing balance

Hot air oven

Soxhlet extractor

Micro-Kjeldhal Apparatus

Desiccator

Table 3.1 Details of variables/parameters, their level and description.

S.no.	Variables/ parameters	Level	Description
1.	Button mushroom	1	*Agaricus bisporus*
2.	Drying air temperature	2	50°C and 70°C
3.	Pre- treatment	3	T1, T2, T3 (5,10,15% NaCl)
4.	Sample size (thickness)	1	1.5cm

5.	Packaging	1	LDPE
6.	Storage condition	1	Ambient

Table 3.2 Quality analysis of osmotic pre- treated dried button mushrooms.

S.no.	Properties	Tests
1.	Physio- chemical characteristics	Moisture content Dehydration ratio Rehydration ratio Drying time Browning index
2.	Sensory evaluation	By 9 point hedonic test

3.2 Method

Button Mushroom were washed with tap water and then kept on blotting paper to remove surface moisture. Mushrooms was cut into slices of 1.5 cm by 3 cm long for the cap after removing the rest part and subjected to osmosis by dipping in brine solutions of 5,10 and 15% for 1 hour and dried by cabinet tray drying method.

Plate 3.1 button mushroom slices

Fresh mushrooms

↓

Sorting and cleaning

↓

Slicing (thickness 1.5cm)

↓

Immersion in brine solution (5%, 10%, 15% for 1 hour)

↓

Draining

↓

Drying(50 and 70^{0}C)

↓

Dehydrated mushrooms (packing in LDPE)

↓

Storage

Figure 3.1 Process flow chart of osmotic dehydration of button mushroom

3.2.1 Physiochemical properties of osmotic pre-treated dried button mushroom

Moisture content (AOAC, 2002)

10 grams of mushroom were dried in hot air oven at 70^{0}C in pre-weighed dishes till constant weight. The dish with dried sample was transferred to desiccators and cooled to room temperature. The dish was then weighed and moisture content in percent was calculated from loss in weight.

Calculation

$$\text{Percent (\%) moisture} = \frac{\text{Loss in weight (g)}}{\text{Weight of sample (g)}} \times 100 \quad \textbf{(3.1)}$$

Dehydration ratio (AOAC, 2002)

Dehydration ratio was calculated by taking the weights of sample before drying and the weight of sample after drying.

Calculation

$$\text{Dehydration ratio} = \frac{\text{Weight of sample before drying}}{\text{Weight of sample after drying}} \quad \textbf{(3.2)}$$

Rehydration ratio (Ranganna, 1986)

The rehydration ratio of dried mushroom flakes was determined by soaking samples with a defined weight (approx. 5 g) in boiling distilled water at 95ºC for 20 minutes. The samples were removed, filtered, dried and weighed. In order to minimize the leaching losses, water bath was used for maintaining the defined temperature

Rehydration ratio (RR) of the samples was computed as follows:

$$\text{Rehydration Ratio} = \frac{Mr}{Md}$$

Where,

Mr = Mass of rehydrated sample (g)

Md = Mass of dehydrated sample(g)

Drying Time

The total time taken for drying of mushrooms was calculated in minutes.

Browning Index (Mudahar and Bains, 1982)

The degree of non-enzymatic browning of the dried mushrooms was determined following the method of Mudahar and Bains (1982). The colour was extracted from dried mushroom using 60% ethanol, and the absorbance of the filtrate was measured using a spectrophotometer at 440 nm.

Total Carbohydrates (Pearson, 1970)

Carbohydrate content of the samples was determined as total carbohydrate by difference that is by subtracting the measured protein, fat, ash and moisture from 100

Sensory evaluation (Amerine *et al.*1965)

Sensory evaluation depends upon the responses given by different sense organs. The samples will evaluated on the basis of appearance, flavour, texture, taste and overall acceptability by semi-trained panel of 9-10 judges by using 9 point hedonic scale assigning scores from 9 as 9 = Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2 = Dislike very much and 1= Dislike extremely. A score of 5.5 and above was considered acceptable .

CHAPTER-IV

RESULTS AND DISCUSSION

The present study was conducted in the Department of Agricultural Engineering, NOVA College, Vijayawada for osmotic dehydration of button mushroom slices. Theprimary processing was done and samples were prepared. The samples were osmotically dehydrated in different concentrations of brine solution on different temperature. The samples were then dried using cabinet tray dryer.

4.1 Effect of Osmotic dehydration on drying characteristics of dried button mushroom slices.

4.1.1 Moisture content:

The moisture content of osmotically dehydrated mushrooms ranged from 7.76 to 8.34 per cent (Table-4.1). The highest moisture content was recorded as 8.34 per cent in T1 (5% NaCl at 50^{0}C) and lowest 7.76 per cent was recorded in T3 (15% NaCl at 70^{0}C). Moisture content was observed to decrease with the increase in NaCl concentration in both drying temperature i.e. 50 and 70^{0}C drying. The moisture content was more in pre-treated 5% NaCl at 50^{0}C dried button mushrooms while it was less in osmotically pre-treated 15% NaCl at 70^{0}C dried button mushrooms. These results are in agreement with the findings of ***Tolera and Abera (2017)*** who reported the highest moisture content in sun-dried mushroomsamples and lowest in oven dried samples. This might be due to moisture absorption of the dried samples from the environment. In sun drying methods, case hardening might occur and causing the moisture content to be higher than samples dried by other drying methods under similar treatment conditions

4.1.2 Dehydration ratio

The dehydration ratio ranged from 10.4 to 13.9 (Table-4.1). The dehydration ratio was highest in T3 (15% NaCl at 70^{0}C drying) value of 13.9 and lowest was recorded as 10.4 inT_1 (5% NaCl at 50^{0}C). There was significant difference in dehydration ratio among various treatments. The dehydration ratio was more in osmotically dehydrated cabinet dried oyster mushrooms as compared to osmotically dehydrated sun dried mushrooms. ***Kumar and Sagar (2014)*** reported that the superior drying ratio was obtained in the fruits dried in cabinet drier. The good result of cabinet drier was due to high temperature.

4.1.3 Rehydration ratio

The highest rehydration ratio was recorded in T3 (15% NaCl 70^{0}C drying) with mean value of 2.56 and lowest in T1 (5% NaCl at 50^{0}C) value 2.14 (Table-4.1). There was significant difference in rehydration ratio among various treatments. Rehydration ratio increased with the increase in salt concentration. It may be noted that higher rehydration ratio indicates better quality product (***Kulshreshtha et al., 2009)***. ***Bhuvaneswari et al. (1999)*** reported that rehydration ratio of osmotically treated peas was higher than those of untreated samples.

Table 4.1: Effect of osmotic dehydration on moisture content (%), dehydration ratio andrehydration ratio of dried button mushrooms:

Treatments	Temperature	Moisture content (%)	Dehydration ratio	Rehydration ratio
T1 (5% NaCl)	cabinet drying (50^0C)	8.34	10.4	2.14
	Cabinet drying (70^0C)	7.98	12.9	2.41
T2 (10% NaCl)	cabinet drying (50^0C)	8.26	11.2	2.24
	Cabinet drying (70^0C)	7.89	13.3	2.48
T3 (15% NaCl)	cabinet drying (50^0C)	8.18	12.6	2.33
	Cabinet drying (70^0C)	7.76	13.9	2.56

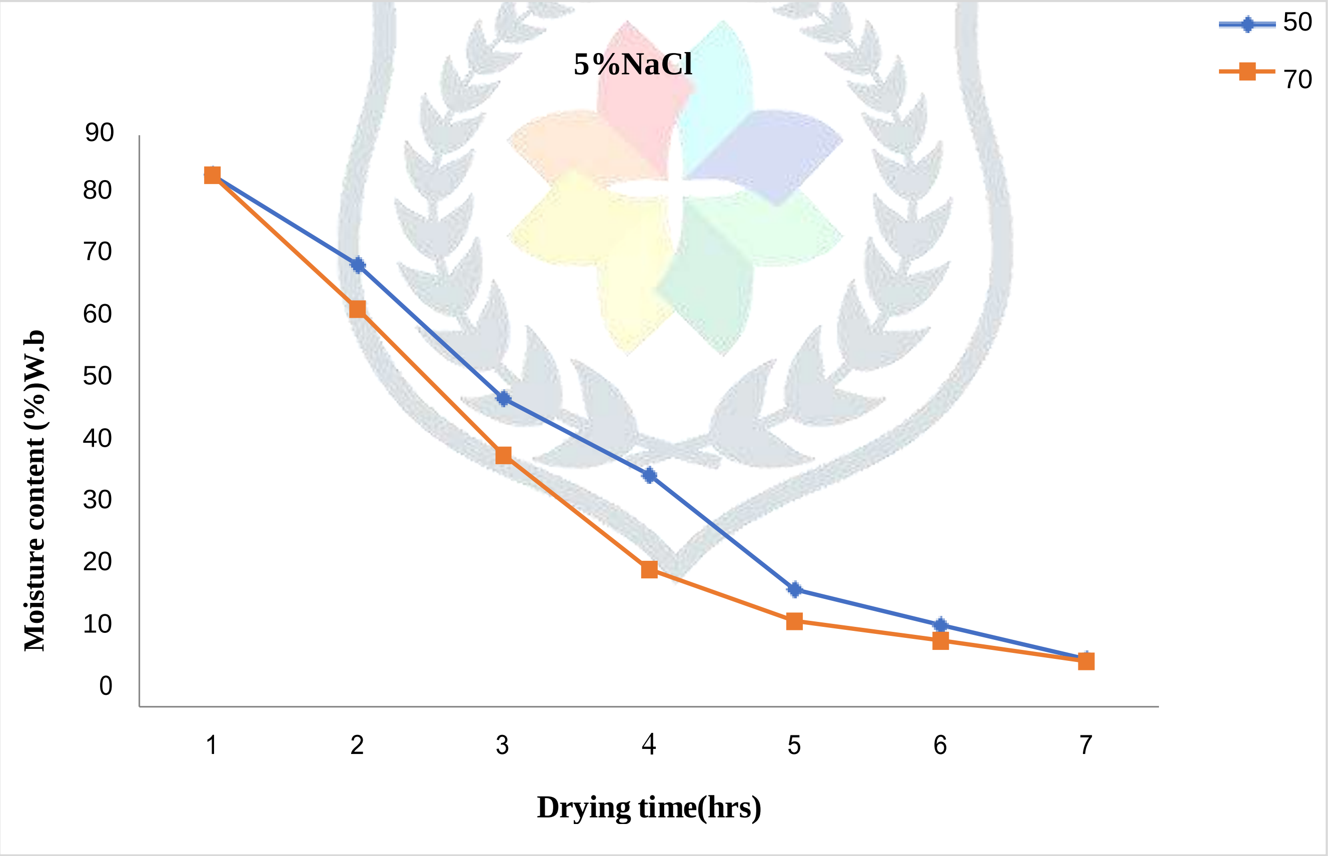

Figure 4.1 Effect of osmotic dehydration on moisture content(5% NaCl).

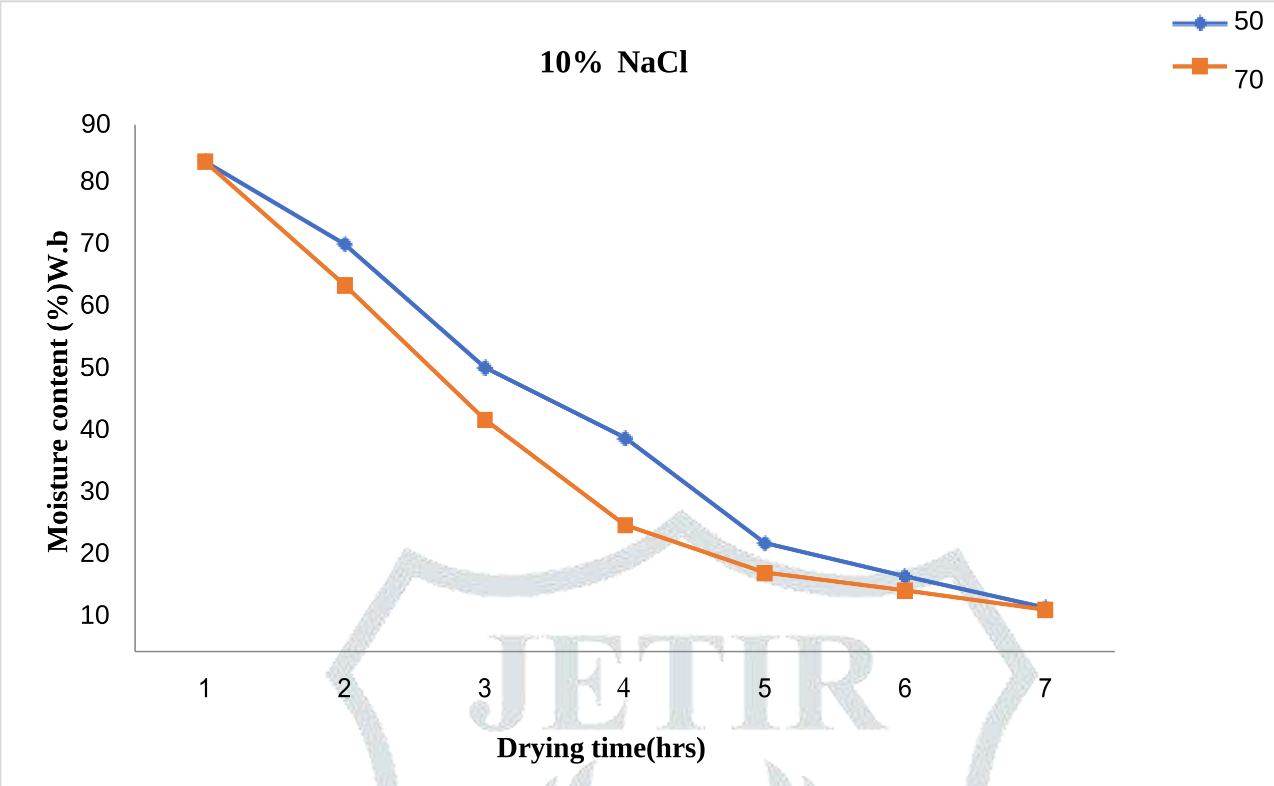

Figure 4.2 Effect of osmotic dehydration on moisture content (10% NaCl).

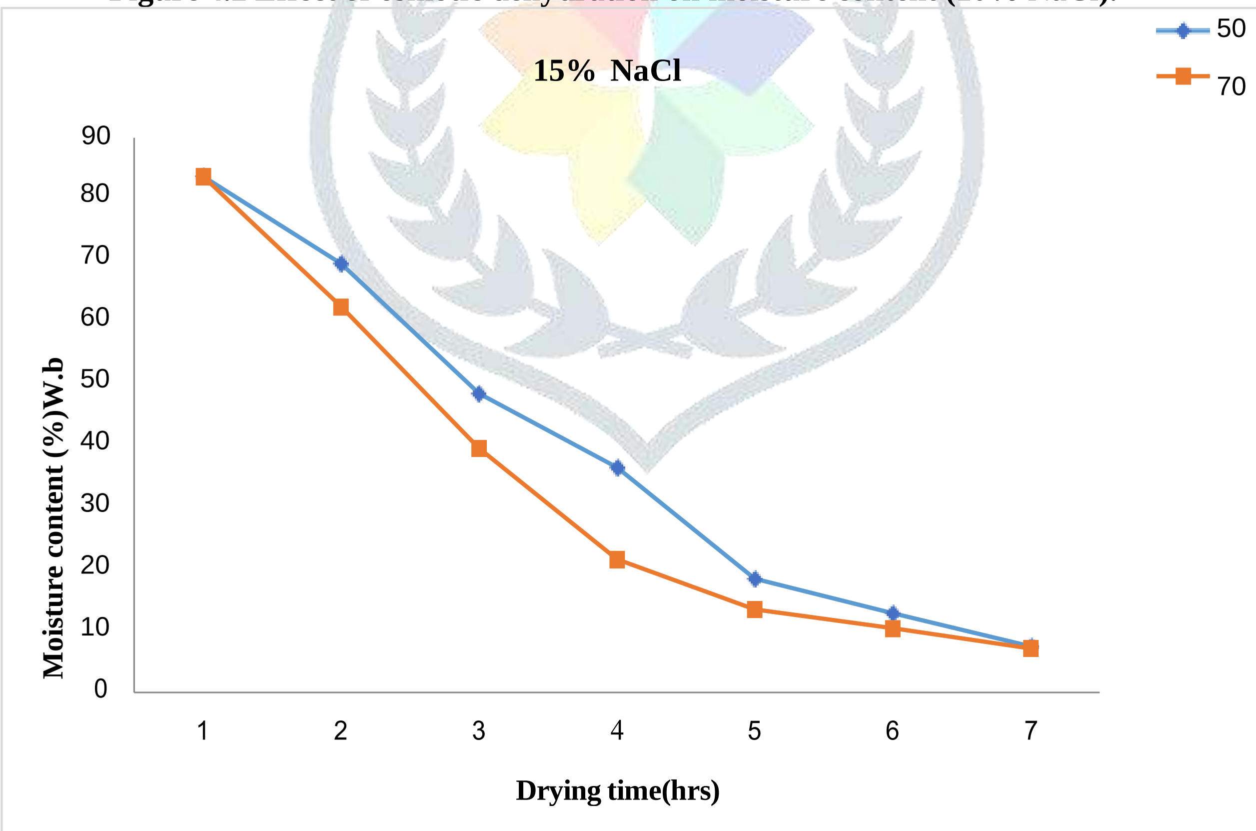

Figure 4.3 Effect of osmotic dehydration on moisture content (15% NaCl).

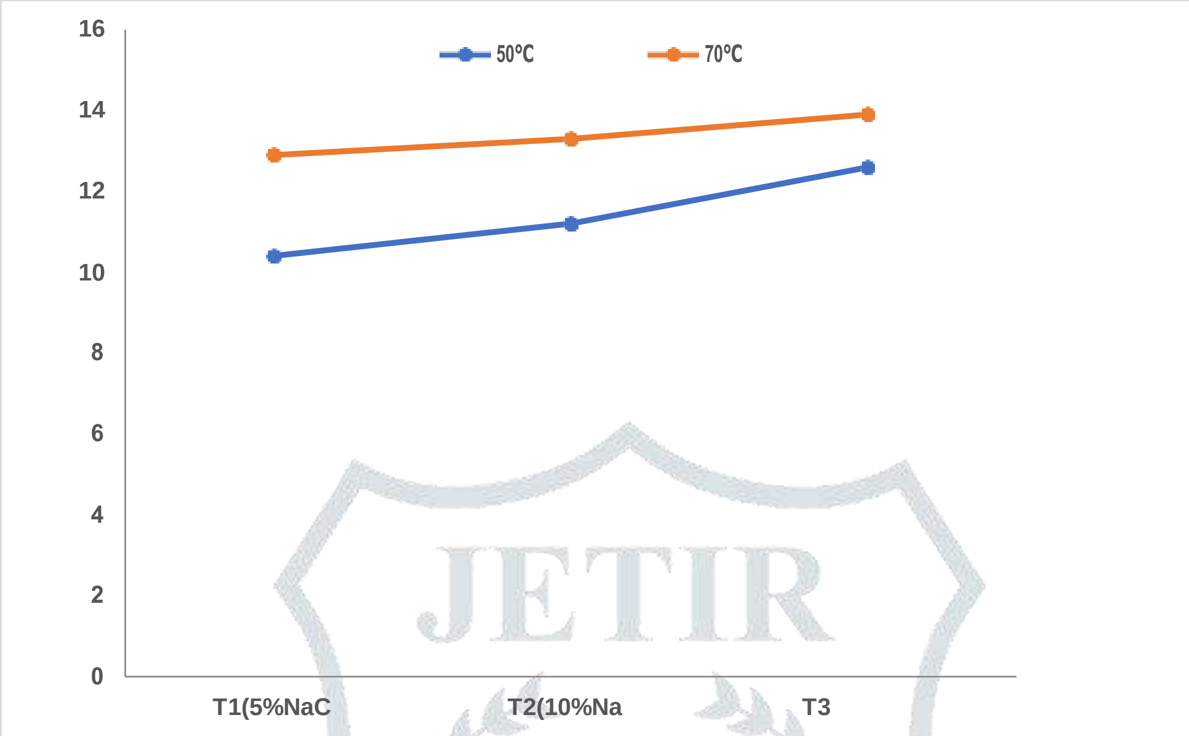

Figure 4.4 Effect of osmotic dehydration on dehydration ratio.

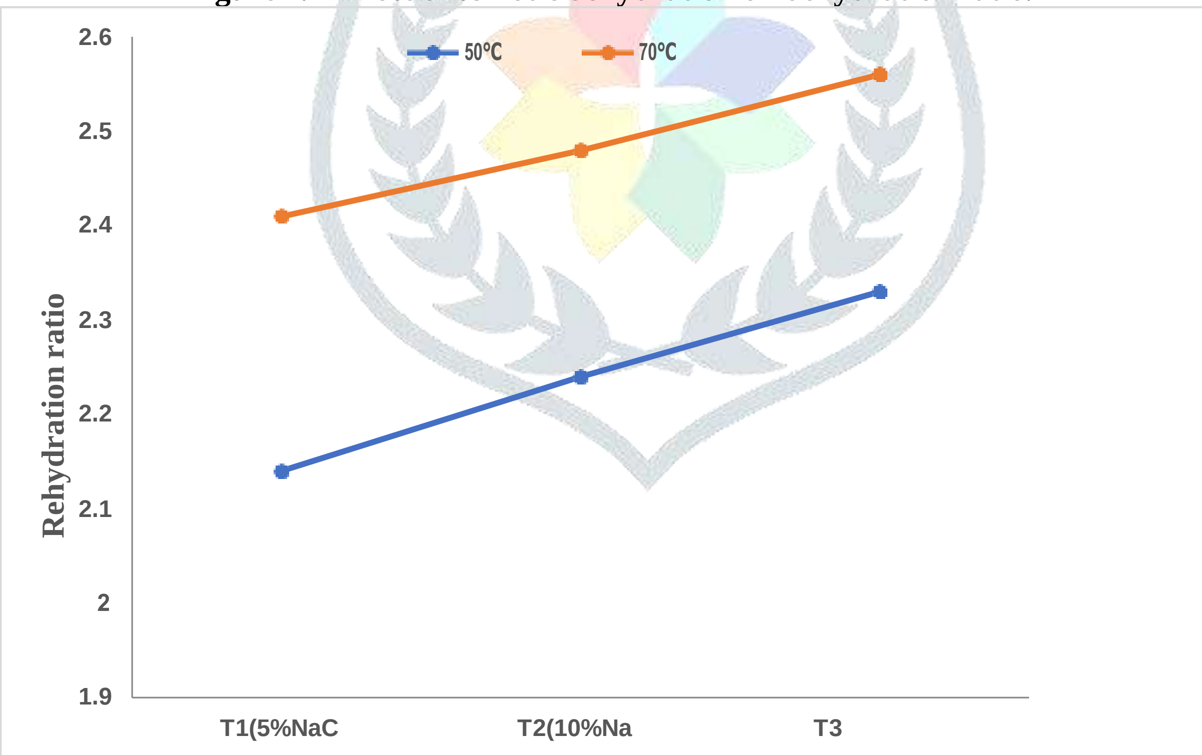

Figure 4.5 Effect of osmotic dehydration on rehydration ratio.

4.1.4 Drying time:

The drying time ranged from 240 to 350 minutes (Table-4.2). The drying time was highest in T1 (5% NaCl at 50^0C) with a mean drying time of 350 minutes and lowest 240 minutes in T3 (15% NaCl at 70^0C). There was significant difference in drying time among various treatments. The total time taken to dry the osmotically pre-treated mushrooms in 5% NaCl (50^0C) was less as compared to pre-treated mushrooms in 15% NaCl (70^0C). This may be due to initial moisture reduction during the osmosis. This is in agreement with the results obtained by ***Kaleemullah et al. (2002)*** in osmotically dehydrated papaya cubes and ***Amuthan et al. (1999)*** in osmosed milky mushrooms *Calocybe indica*

4.1.5 Browning index:

Browning index of mushrooms decreased with the increasing concentration of sodium chloride in dipping solutions. It was maximum 0.41in T1 (5% NaCl at 50^0C) and minimum 0.22 in T3 (15% NaCl at 70^0C). There was significant difference in browning in colour when compared to the pre-treated samples regarding the study of osmotic dehydration pre-treatment for drying of pumpkin slices.

Table 4.2: Effect of osmotic dehydration on drying time (minutes) and browning index of dried button mushrooms.

Treatments	Temperature	Drying time (minutes)	Browning index
T1 (5% NaCl)	cabinet drying (50^0C)	350	0.41
	Cabinet drying (70^0C)	260	0.29
T2 (10% NaCl)	cabinet drying (50^0C)	340	0.35
	Cabinet drying (70^0C)	250	0.26
T3 (15% NaCl)	Cabinet drying (50^0C)	330	0.32
	Cabinet drying (70^0C)	240	0.22

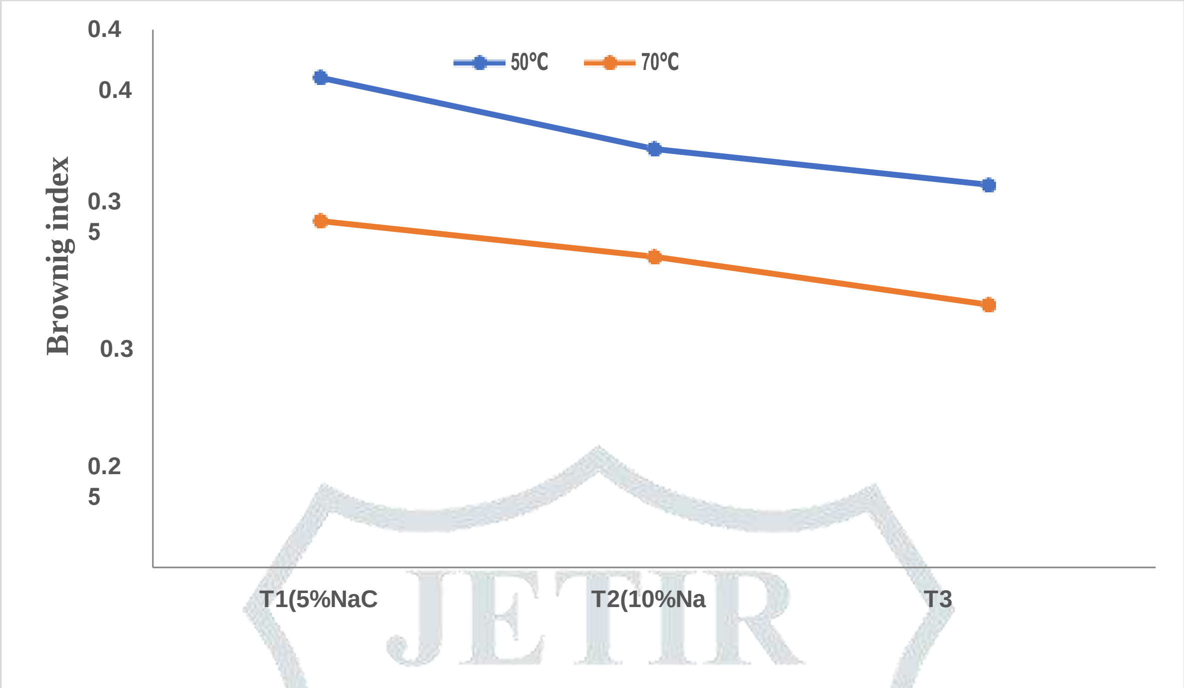

Figure 4.6 Effect of osmotic dehydration on browning index

4.2 Effect of osmotic dehydration on organoleptic attributes of dried button mushroom.

Table 4.3 Sensory evolution of mushroom slices is treated with different concentration of salt solution on different temperature.

Treatments	Temperature	Colour	Texture	Taste	Overall acceptability
T1 (5% NaCl)	Cabinet drying (50°C)	7.3	7.3	7.5	7.1
	Cabinet dying(70°C)	7.3	6.9	7.6	7.2
T2 (10% NaCl)	Cabinet drying (50°C)	7.1	7.9	7.8	7.2
	Cabinet dying (70°C)	7.7	8.2	7.8	7.3
T3 (15% NaCl)	Cabinet dying(50°C)	6.4	7.4	6.9	7.3
	Cabinet (70°C)	7.9	8.7	7.1	7.5

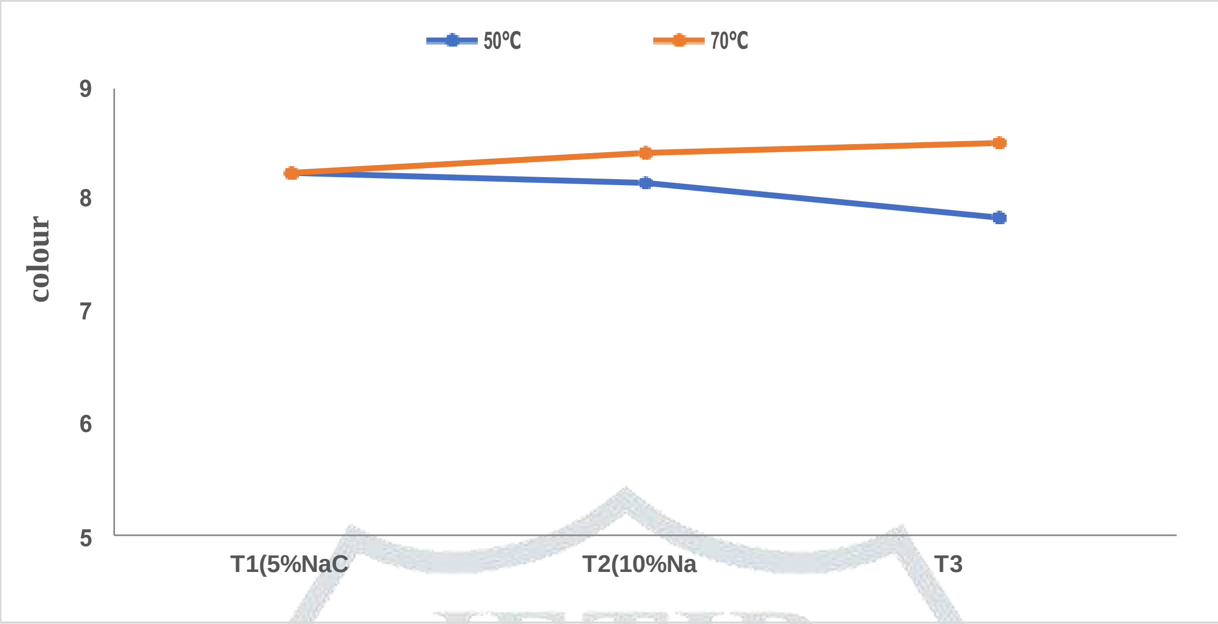

Figure 4.7 Effect of osmotic dehydration on colour and appearance.

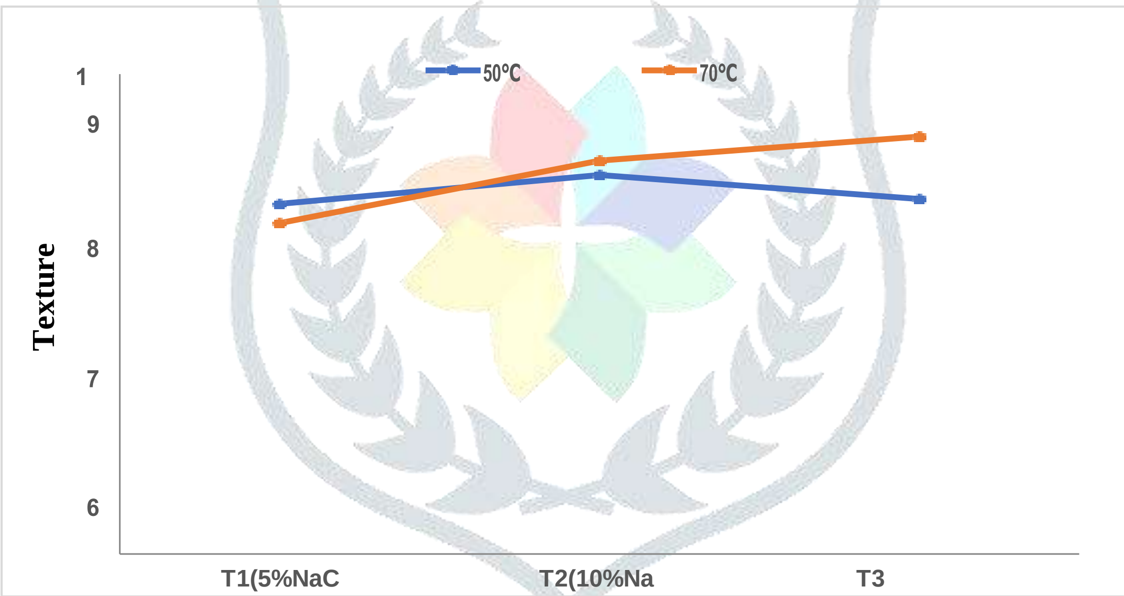

Figure 4.8 Effect of osmotic dehydration texture.

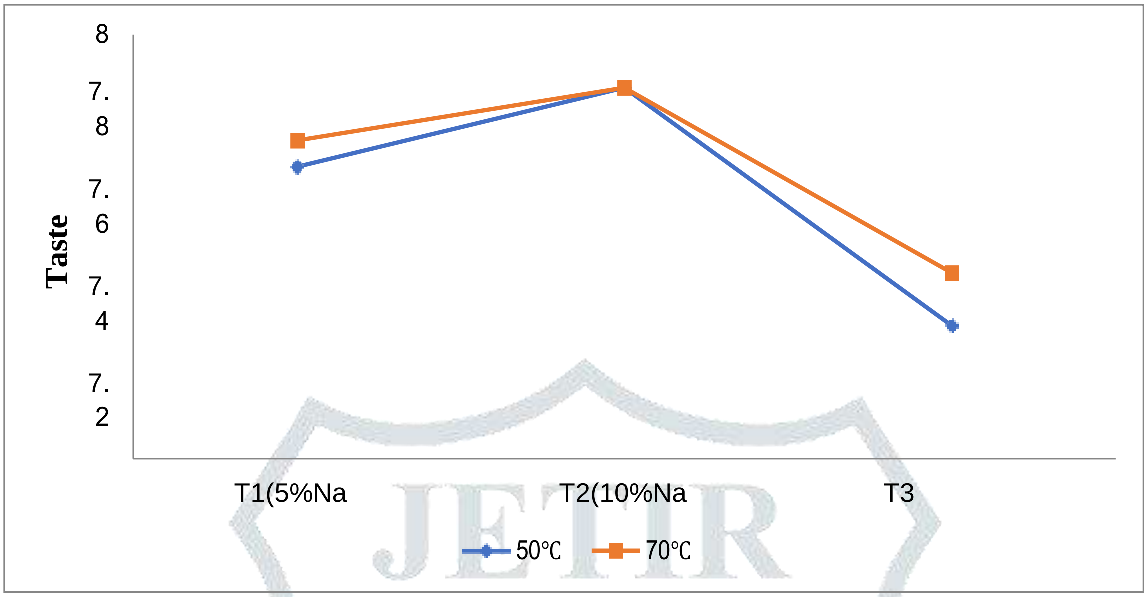

Figure 4.9 Effect of osmotic dehydration on taste.

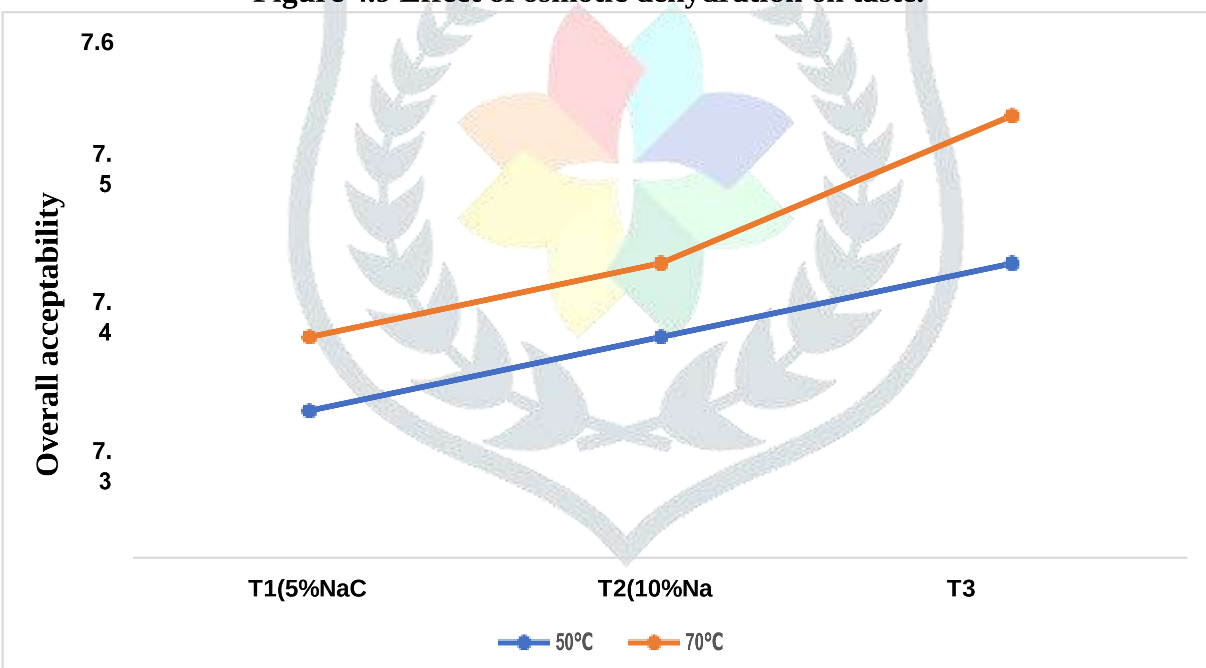

Figure 4.10 Effect of osmotic dehydration on overall acceptability.

CHAPTER -V

SUMMARY AND CONCLUSION

The study aimed to investigate the impact of osmotic dehydration on the quality of button mushrooms. Slices of button mushrooms were prepared by immersing them in brine solutions of varying concentrations (5%, 10%, and 15%) for one hour, followed by drying in a cabinet tray dryer at temperatures of 50°C and 70°C. Quality assessment was based on drying characteristics such as moisture content, drying time, and sensory attributes including color, texture, taste, and overall acceptability.

Moisture content decreased with increasing brine concentration and drying temperature, indicating improved dehydration efficiency. Dehydration ratio increased with higher brine concentration and temperature, suggesting enhanced moisture removal.

Rehydration ratio exhibited an increase with rising salt concentration, implying better quality preservation. Drying time and browning index decreased with higher sodium chloride concentration in the dipping solutions and drying temperature, indicating improved product quality.

The nutritional analysis revealed a decrease in crude protein content from 26.94% to 23.11%, with the highest crude fat content (2.23%) observed in samples treated with 5% NaCl at 50°C and the lowest (1.72%) in samples treated with 15% NaCl at 70°C. Total ash content ranged from 5.23% to 7.87%, with the highest recorded in samples treated with 15% NaCl at 70°C and the lowest in samples treated with 5% NaCl at 50°C. Carbohydrate content increased with osmotic concentration, with the highest value (59.53%) observed in samples treated with 15% NaCl at 70°C.

The sensory evaluation indicated that the highest average scores for color, texture, taste, and overall acceptability were observed in button mushroom slices dried at 70°C after osmotic pre-treatment with 15% NaCl, with scores of 7.9, 8.7, 7.1, and 7.5, respectively.

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