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Effect of Osmotic and Pickling Pretreatments on Nutritional Quality and Acceptance of Traditional Fermented Oyster Mushrooms

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Abstract
The study was conducted to evaluate the pretreatment effects of ascorbate and osmotic solution on oven dried and pickled mushrooms. Significant differences in nutritional composition and sensory quality were observed between the pickled and dried samples of mushrooms. Pickling obtained in high moisture content, crude fibre, crude fat, crude protein, soluble solid and ash content, however, the content of carbohydrates and dry matter were lower than oven drying. Both osmotic and ascorbate pretreatments significantly affected the composition. As result, ascorbate concentration increased the protein, ash and fat contents of mushroom samples. In contrary to ascorbate pretreatment, osmotic solution pretreated mushrooms resulted in highest rehydration capacity. The sensory evaluation results of the pickled mushrooms products had more acceptances and acquired good colour, flavour and overall acceptability than that of oven dried products. Ascorbate treatments combined with pickling are advantageous in terms of mushroom quality as compared to oven drying methods and osmotic pretreatments. Unlike osmotic pretreatments, the mushrooms that were pretreated in ascorbate were maintained their nutritional compositions, acidity and physical quality.
Keywords: Ascorbate, osmotic, pretreatments, mushroom, pickling, oven drying, nutritional quality, consumer acceptability

Introduction

Mushrooms are an important food item known worldwide, whose production has been increasing from time to time. However, a thorough understanding about the consumption trend is in its infant stage, particularly in developing countries. In developing countries, the importance of edible mushrooms within consumer preferences and perceptions has not been studied in detail. During the past few decades, major efforts in the cultivation of edible mushrooms have been focused on technological developments and yield (Yésica *et al*., 2006).

Mushroom cultivation can contribute to improve livelihoods through economic, nutritional and medicinal contributions. However, it is essential to note that some mushrooms are poisonous and may even be lethal, thus the need for extra caution in identifying those species that can be consumed as food (Canford, 2004). Mushrooms both add flavourto bland staple foods and are a valuable food in their own right: they are often considered to provide a fair substitute for meat, with at least a comparable nutritional value to many vegetables. The consumption of mushrooms can make a valuable addition to the often unbalanced diets of people in developing countries. Fresh mushrooms have high water content (90 %), so drying them is an effective way to both prolong their shelf-life and preserve their flavourand nutrients (Canford, 2004). Mushrooms are rich in protein compared with other vegetables, and its production can be one of the most promising and highly desirable activities in developing countries to reduce protein malnutrition (Quimio *et al.*, 1990) and are a good source of vitamin B, C and D, including niacin, riboflavin, thiamine, and folate, and various minerals including potassium, phosphorus, calcium, magnesium, iron and copper (Kurtzman, 1997).

They provide carbohydrates, but are low in fat and fibre, and contain no starch. In addition to all the essential amino acids, some mushrooms have medicinal benefits of certain polysaccharides, which are known to boost the immune system (Canford, 2004). Therefore, if the production of mushroom is increased in the country, it will help to provide balanced nutrition for the small-scale (marginally poor) farmers, where mostly they are undernourished, because they seldom eat food. And even the foods that they are taking are mainly cereals sources (poor in proteins and vitamins). Thus, producing mushroom could directly help the farmers who produce it and will also indirectly help them as a source of income by selling it and ultimately help will for food-sufficiency of the poor people who live in the country (Henok *et al.*, 2011).

Ethiopia has the potential to grow oyster mushrooms due to the presence of huge amount of agricultural and forest wastes and suitable environment which support the growth of mushrooms. Currently,

several species and varieties of oyster mushrooms are being cultivated in many parts of the world. In Ethiopia, oyster mushrooms are the first to be introduced in to the market (Dawit, 1998). However, the perishable nature of oyster mushrooms means they have very short shelf life and low quality. Normally mushrooms are consumed fresh or preserved in different ways of drying and pickling with vinegar (Rastogi *et al.*, 2004). Drying is the easiest means to extend the shelf life of mushroom. In addition, soaking mushrooms with ascorbate and osmotic solution for 30 minutes prior to drying and pickling are convenient for long-term storage and most popular. Mushrooms preserved by drying and pickling have a good flavour, texture and significantly increases the nutritional and sensory quality (Rastogi *et al.*, 2004). Thus, this research was designed to improve the nutritional quality and sensory acceptance of oyster mushrooms through pretreatments and processing methods.

Materials and methods

The oyster mushroom was grown and obtained from the greenhouse at Haramaya University research Farming, Ethiopia. The oyster mushroom was selected for its common consumption and preference of small scale production (Henock *et al.,* 2011). All analyses were carried out at the Nutrition and Food Science and Post Harvest Technology Laboratories, Haramaya University from August-October 2013.

Experimental procedures and sample preparation

Mushrooms were harvested in early morning and preparations started within an hour and were washed thoroughly under running tap water to remove microbial load, field ruminants and adhering soil particles. The cleaned mushroom samples were sliced manually into thin slices (Argyropoulos *et al.*, 2008) using stainless steel knife prior to ascorbate and osmotic solution pretreatments. Following this, ascorbate (5%) and osmotic solution (10%) were used as pretreatment of mushroom slices prior to pickling and drying.

The prepared mushroom samples (16 kg) were soaked in 5% and 10% ascorbate and NaCl (Torringa, 2001), respectively, at ambient temperature for 30 minutes ensuring full coverage of the slices by the solution. After the ascorbate and osmotic pre-treatments, the samples were withdrawn and cleaned gently with tissue paper (absorbent) in order to remove excess water on the surface. The whole prepared slices of mushroom samples were divided for pickling and oven drying. Half of the portions of prepared slices of mushroom samples were prepared for pickling.

The resulting pretreated slices were mixed with other ingredients consisting of onion chopped (25 g), cardamom powder (25 g) and cumin powder (15 g) in a large pan and was homogenized occasionally until a very soft product was attained. Then, the whole mixture was mixed with common salt (50 g). After doing this, the mixture was brought to minimal boil and the boiling continued at 60 °C for 10 minutes.

At the end, white vinegar (300 ml) was added by allowing it to bubble gently through careful stirring until thoroughly blended and good flavoured pickle was formed. The final pickled product was filled in pre-sterilized air tight jars and kept for sensory and nutritional analysis.

The other portion of the prepared slices of mushroom samples were spread on stainless steel trays and dried in hot air oven at 60^{o}C (Argyropoulos *et al.*, 2008). The samples was dried and kept in an oven until required moisture content of about 13% was achieved. The dried mushroom slices were packed and sealed in polyethylene plastic bags. The packed samples were stored in a dry place and stored at room temperature until they were required for sensory and nutritional analysis.

Physico-chemical analysis

Moisture content

A crucible was dried in an oven at 130^{o}C for 1 hour and placed in desiccators to cool. The weight of the crucible (W_1) was determined. Sample was weighed in the crucible (W_2) and dried at 130^{o}C for 1 hour. After cooling in desiccator to room temperature it was again weighed (W_3). The moisture content was determined as follows:-

$$\text{Moisture conent (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Chemical analysis

Crude fibre determination

About 3 g sample (M_3) was weighed and transferred to 1000 ml beaker. After digestion with 1.25% sulfuric acid it was washed with distilled water and again digested by 1.25% sodium hydroxide. Then it was filtered in coarse porosity (75 µm) crucible in apparatus at a vacuum of about 25 mm. The residue left after refluxing was washed again with 1.25% sulfuric acid near boiling point. This residue was dried at 110^{o}C for about 2 hrs, cooled in desiccators and weighed (M_1). After ashing for 2 hrs at 550^{o}C, it was cooled in a desiccator and weighed again (M_2). Then, the total crude fibre was expressed in percentage as:

$$\text{Crude fiber} = \left(\frac{M_1 - M_2}{M_3}\right) \times 100$$

Crude fat determination

Crude fat (CF) was determined by using soxhlet extraction method in which solvent (n–hexane) extraction and separation of fat from samples was achieved by continuous evaporation and condensation of the solvent. Mushroom sample of 2 g was weighed using analytical balance (W_1) and transferred into an extraction thimble. The thimble was carefully placed in a soxhlets' extractor (type EV-16, Gerhardt Bonn, Germany). The soxhlets' extractor carrying the thimble was fitted in a previously weighed extractor flask (W_2). Sufficient amount of n–hexane was poured into the extractor until it began to siphon off. The extractor was refilled to about half after all the previously poured ether was siphoned off to the flask. The top of the thimble was kept above the siphon height of the solvent in order to avoid the wash off of the samples to the flask. The extraction flask and the extractor were placed firmly with help of a clamp on a heating unit to boil the solvent. The condenser was connected to the extractor with its top hole plugged with a thin layer of defatted cotton. A continuous flow of cold water was applied through the condenser. The heating unit was switched on and the extraction was allowed to proceed. The n–hexane started vaporizing and the vapors passed up to the condenser through the side of the extractor.

The vapor condensed in the condenser and dropped on the thimble until its level reached the siphon height, whereby the whole solvent in extractor was recycled to flask along with the fat extracted from the sample. The process continued for about 6 hours and the thimble was removed from the extractor. The n–hexane was collected and the remaining solvent in flask was evaporated in a steam bath and then the oil flask was transferred into oven and kept at 100°C for complete evaporation of solvent. The oil flasks were transferred into desiccators for cooling to room temperature and weighed (W_3). Finally, percent of crude fat was calculated as follows:

$$\text{Crude fat} = \frac{W_3 - W_2}{W_1} \times 100$$

Where:

W_1 = weight of the extraction flask (g)
W_2 = weight of the extraction flask plus the dried crude fat (g)
W_3 = weight of sample in g on dry matter basis (db)

Crude protein determination

Both ground (by mortar and pestle) samples of dried and pickled oyster mushroom (*P. ostreatus*) were analyzed for crude protein from each treatment. The total nitrogen content of the sample was analyzed by micro-kjeldahl method as described in AACC (2000) Method № 46 – 11. Mushroom samples (0.5 g) were placed in to digestion flask containing 2.5 mL of the mixture of (H_2SO_4 + Se (100 mL) and salicylic acid (7.2 g) and 3 pieces of boiling chips. The content of the flask was digested to temperature of 350°C on digestion apparatus until the digestion completed and the digest gets clear. The acid digest was allowed to cool at room temperature. The digested sample was transferred to distillation unit (Model UDK-142, Europe). Distillation was performed by adding 30 mL of distilled water followed by 25 mL (40% NaOH) and connecting it to distillation apparatus whose outlet tube was immersed in 25 mL of 4% boric acid solution. The distillate (about 150 mL) was collected and titrated by standard acid (0.1N HCl). The volume of HCl consumed was taken from the burette reading. Finally, the N% was calculated by the equation described below. Urea was used as a control in the analysis.

$$N(\%) = \left(\frac{V_{HCl} \text{ in L} \times N_{HCl\,(ca\ 0.1)} \times 14}{\text{Sample weight(g, db)}}\right) \times 100$$

$$P\,(\%) = F \times N(\%)$$

Where:

N = Nitrogen
V_{HCl} = Volume of HCl used during titration (Lit)
N_{HCl}= Normality of HCl (0.1 N)
14 = Molecular mass of nitrogen
P = Protein (%)
F = Conversion factor (6.25)

Total ash content determination

Total ash (TA) content of oven dried mushroom samples was determined according to AOAC (1995) Method No. 923-09. Porcelain dish was cleaned, dried at 120°C in an oven and ignited at about 550°C in muffle furnace for 3 hrs and cooled in a desiccator and weighed (m_1). Then 3 g sample of mushroom powder was put into the

porcelain dish and weighed (m_2). This sample was dried at 120°C for 1hr and carbonized by blue flame of Bunsen burner. The dish with its contents was transferred to muffle furnace and ignited at about 550°C for 6 hours. The residue was weighted (m_3). Then total ash was expressed as percentage on dry basis as follows:

$$\text{Total ash (\%)} = \frac{m_2 - m_1}{m_3 - m_1} \times 100$$

Where: (m_2-m_1) is sample mass in g on dry base and (m_3-m_1) mass of ash in g.

Rehydration Capacity

The rehydration capacity of oven dried mushroom samples was assessed by immersing about 20 g of dried mushroom samples in distilled water at 25˚C for 10 minutes (Lewicki, 1998). The dry mass of the rehydrated sample was determined by drying the samples in a conventional oven at 105 for 2 h. The rehydration capacity (given as the ratio of the weight of water absorbed during rehydration to the weight of water removed in dehydration multiplied by 100) has finally been calculated as shown below (Doymaz, 2004).

$$\text{Rehydration capacity} = \frac{\text{Weight of water absorbed during reconstitution}}{\text{Weight of the water removed during drying}} \times 100$$

The weight of the water removed during the drying process is the difference of the initial weight of the fresh sample before drying and the final weight of the sample after the drying is complete and determined as follows:

$W_{wr} = W_{wi} - W_{wf}$

Where:

W_{wr} = weight of the water removed during drying
W_{wi} = initial weight of the sample before drying
W_{wf} = final weight of the dried sample after drying

The weight of water absorbed during rehydration is the difference of final weight of the sample after rehydration and initial weight of the sample before rehydration.

$W_{wa} = W_{wr} - W_{dr}$

Where:

W_{wa} = weight of the water absorbed during rehydration
W_{wr} = final weight of the sample after rehydration
W_{dr} = initial weight of the dry sample before rehydration

Soluble solid loss determination

The soluble solid loss into the water during rehydration was directly measured (in degree Brix (°B)) using a digital pocket refractometer by putting a drop of the water used for rehydration on to the prism being rinsed with distilled water and dried with tissue paper before and in between each test.

Dry matter content determination

The dry matter content of both pickled and dried mushroom was determined by drying the sample in hot air oven at 90°C for 14 hours (Rastogi *et al*., 2004). The ratio of the weight of the dry matter to the initial weight of the sample was calculated and presented in percent as follows:

$$W\ (\%) = \frac{W_2}{W_1} \times 100$$

Where

W= dry matter (%)
W_1= initial weight of samples (g)
W_2=dry matter weight of samples (g)

Sensory evaluation

Descriptive sensory evaluation was used in the screening of pickled and dried mushroom based on their sensory quality characteristics. A total of 20 panellists were involved in the sensory evaluation using five point hedonic scales. Pickled and dried mushroom samples were presented for panellist to evaluate the taste, colour, flavour and overall acceptability of the samples. During the evaluation period, the panellist attended two sessions. Eight samples were served at each session and then all panellists were allowed to taste and evaluate the samples for each quality feature using rating scale. All panellist were instructed to make their own individual assessments according to the evaluation criteria provided for each samples on the basis of taste, colour, flavourand overall acceptability. Finally, the scores of all judges were added and divided by the number of judges to find the final mean score.

Statistical Analysis

A factorial combination of the one mush room variety, two processing methods and two pretreatments was used in the study. The difference between the treatments was determined by the analysis of variance for factorial experiment using SAS.

Results and discussion

Moisture content

Table 1 showed, the moisture content from pickled and dried mushroom showed remarkable differences. Both treatments and processing methods showed significant difference in moisture of mushroom products. The interaction effect of processing methods and treatments significantly ($p<0.05$) affected the moisture content of mushroom slices. The effect of pretreatment subjected with different processing resulted in great moisture variation for the mushroom. The highest moisture percent was recorded for mushrooms pretreated with osmotic solution at 10 % subjected with pickling while the lowest value was obtained from mushrooms pretreated with ascorbate solution at 5 % subjected with oven drying.

On the other hand, mushrooms pretreated by osmotic solution and processed by pickling have higher moisture than that of mushrooms pretreated by ascorbate solution processed by oven drying. This might be due to the processing method effect on moisture loss. Therefore, the study revealed that mushrooms processed by pickling have higher moisture than mushrooms processed by oven drying method. This might be associated to oven drying reducing the moisture due to heat effect and removal of bulk moisture from the samples.

The general trend observed from the study was that the moisture percentage of mushrooms were affected by pretreatments and mushrooms pretreated with ascorbate showed lower moisture than mushrooms pretreated with osmotic solution. This is possibly due to the use of ascorbate solution as pretreatment prior to processing migrates than osmotic solution in to the sample and incline the desiccation effect (Hamid *et al*., 1996).

Crude fibre content

The crude fibre content of pickled and dried mushrooms is presented in Table 1. The crude fibre content was not significant difference due to pretreatment effect. However, slight variation in crude fibre content was observed among pretreatment and processing methods. On the other hand, the crude fibre content did not vary due to pretreatment of ascorbate and osmotic solution.

The interaction effect of pretreatment and processing method affected crude fibre content of mushrooms. High value (10.21 %) in crude fibre was obtained for mushrooms pretreated by osmotic solution at 10 % than ascorbate solution at 5 %. Generally the mean value of crude fibre observed from this study was decreasing with pretreatment with ascorbate solution.

It appears that ascorbate concentrates had influence in the decreasing of crude fibre due to increasing the solubility of fibers in the sample (Gormley *et al.,* 1997). The fibre content of mushroom samples highly increased when processed by oven drying than pickling and this is resulted due to the drying effect increase the fibre content also positively increased, however, mushrooms processed in pickle method after pretreated with osmotic solution have high value than that of pickled mushrooms pretreated by ascorbate solution. This indicates that ascorbate pretreatments have remarkable effects on crude fibre difference for the same processing method used for mushrooms. Generally the mean value of crude fibre observed from the study was decreasing with the increase of the concentration of ascorbate solution.

Crude fat content

As presented from Table 1 the crude fat content of mushrooms exhibited a difference among pretreatment and processing methods. The crude fat results obtained from the study presented that crude fat values were affected by pretreatment solutions in the interaction with the processing methods. The highest value (2.42 %) in crude fat was recorded for mushrooms pretreated by ascorbate subjected with pickling as opposed to mushrooms pretreated by osmotic solution processed by oven drying. On the other hand, mushroom samples processed in pickling have higher value than mushrooms processed in oven drying which were pretreated with both ascorbate and osmotic solution.

Among processing methods, mushroom samples processed in pickling method have higher fat content than that of oven dried mushrooms after the same pretreatment used. However, osmotic solution pretreated mushrooms subjected with both pickling and oven drying have maximum crude fat values. This might be due to ascorbate having positive effect on fat degradation than osmotic concentrates and result lowering of fact content in the samples. In addition to pretreatment effect, oven drying also has a fat decreasing relationship due to thermal breakdown of fat available in the samples (Ragunatha *et al*., 2003).

Crude protein determination

Table 2 shows the interaction effect of pretreatment and processing method on crude protein content of

mushroom samples. Pickling method for mushrooms pretreated with ascorbate solution obtained the highest crude protein content. Accordingly, pickling method showed high crude protein content of mushrooms pretreated with both ascorbate and osmotic solution. The maximum (27.14 %) in crude protein content was obtained for mushrooms pretreated with ascorbate solution subjected with pickling while the minimum value (24.95 %) was founded from mushrooms pretreated with osmotic solution processed by oven drying.
Concerning processing methods, mushrooms processed by oven drying after pretreatments with ascorbate and osmotic solution showed the lower crude protein content. This is related with oven drying which has great effect on thermal protein denature and resulted in lowering the contents. In spite of this, pickling does not have any effect on protein denature and maintains the protein available in the samples.

Ascorbate pretreated mushrooms subjected with both pickling and oven drying obtained lower crude protein content than osmotic pretreated mushrooms. This might be because osmotic concentrations have more protein hydrolysis effect than ascorbate and that results in high crude protein contents.

Determination of carbohydrate content

The total carbohydrate content of mushrooms used in the study was found to be between 59.99% maximum and 43.08% minimum, respectively. The interaction effect of pretreatment and processing method affected carbohydrate content of mushrooms significantly ($p<0.05$).

The carbohydrate content of mushroom pickle prepared from osmotic pretreatments was the highest of all, while the lowest carbohydrate contents were obtained in mushroom pickle prepared from ascorbate solution. On the other hand, both types of mushrooms processed by pickling and oven drying obtained higher value in carbohydrate after being pretreated by osmotic solution than that of mushrooms pretreated by ascorbate solution. The effect of osmotic pretreatment in the study affected carbohydrate content highly in all types of mushroom processed in pickling and oven drying than that of ascorbate pretreatments. This might be due to osmotic solutions having the potential to depolymerize the carbohydrate chains and increase the availability of carbohydrate in the samples (Sueli *et al.*, 2002).

Oven drying reduced the carbohydrate content of all mushrooms after being pretreated by ascorbate and osmotic solution. These are due to thermal drying degrading the components of samples and decrease the available carbohydrates. However, mushrooms obtained from oven drying pretreated with ascorbate were found with higher carbohydrate content than mushrooms processed by oven drying pretreated with osmotic solution. This might be due to the effect of pretreatment on carbohydrate difference for mushrooms processed by the same oven drying method (Sueli *et al.*, 2002).

Total ash content determined

As can be seen from Table 2, the interaction effect of pretreatment and processing method affected ash content of mushrooms significantly. The total ash content of mushrooms used in the study was found to be between 15.77% maximum and 2.12% minimum, respectively.

The ash content of mushroom pickle prepared from ascorbate pretreatments were the highest of all, while the lowest ash contents were obtained in oven dried mushroom prepared from osmotic solution. In addition, there was difference in ash content between mushrooms processed at pickling and oven dry method after pretreated with ascorbate and osmotic solutions. On the other hand, pickling was obtained high ash content for mushrooms pretreated with ascorbate and osmotic solutions. It is well known that pickling did not affect the entire nutrient content of foods, rather it improves the preservative quality and sensory acceptability (Yusuf *et al.*, 2008).

The ash content of mushrooms pretreated with ascorbate was higher than that of mushrooms pretreated with osmotic solution. This is due to ascorbate having mineral degradation and maintains the total ash available in the samples. However pretreatment such as osmotic solutions potentially degrade the minerals in the sample and reduce the available ash of the product. On the other hand, the ash content of the mushrooms increased with pretreating in ascorbate solution than osmotic treatment.

Concerning processing method, oven drying reduced the ash content of all mushrooms after being pretreated by ascorbate and osmotic solution. This is due to oven drying degrading the mineral component of samples and decreasing the available ash (Yusuf *et al.*, 2008). However, mushrooms obtained from oven drying and pretreated with ascorbate were found with higher ash content than mushrooms processed by oven drying pretreated with osmotic solution. This might be due to the effect of pretreatment on ash difference for mushrooms processed by the same oven drying methods. This clearly showed that oven drying significantly ($p<0.05$) affected the total ash contents of pickled mushroom slices.

Dry matter content determination

The data of dry matter content of pickled and dried mushroom slices obtained in this study was presented in Table 3. The dry matter content of mushrooms used in the study was found to be between 93.28 % maximum

and 90.42% minimum, respectively. As obtained from the study the interaction effect of pretreatment and processing method affected dry matter content of mushrooms significantly ($p<0.05$).

The dry matter content of dried mushroom prepared from ascorbate pretreatments were the highest of all, while the lowest ash contents were obtained in pickled mushroom prepared from osmotic solution. In addition, there was difference in ash content between mushrooms processed at pickling and oven dry method after being pretreated with ascorbate and osmotic solutions. On the other hand, oven drying, obtained high dry matter content for mushrooms pretreated with ascorbate and osmotic solutions.

This is well known that oven drying increases the dry matter content of foods when processed to new products. This is due to drying increase evaporation and imparts the dry content after bulk removal of moisture from the samples.

The general trend found in the study was the dry matter content of mushrooms was different among pretreatment effect. The dry matter content of mushrooms pretreated with ascorbate were the highest value after being subjected with pickling and oven drying compared with that of mushrooms pretreated with osmotic solution subjected with the same processing methods. This is associated with ascorbate have good drying potential than osmotic solution and imparts the dry matter content.

Rehydration capacity

The data presented from Table 3 shows the rehydration capacity of mushrooms were affected by interaction effect of pretreatments and processing methods. The interaction effect of both ascorbate and osmotic pretreatment followed by pickling and oven drying method affected rehydration capacity of mushrooms significantly ($p<0.05$).

The rehydration capacity of dried mushroom prepared from both osmotic and ascorbate pretreatments were the highest of all, while the lowest rehydration capacities were obtained in pickled mushroom prepared from osmotic solution. In addition, there was a difference in rehydration capacity between mushrooms processed at pickling and oven dry method after pretreated with ascorbate and osmotic solutions. On the other hand, oven drying obtained high dry matter content for mushrooms pretreated with ascorbate and osmotic solutions.

This might be due to oven drying increasing the dry matter content of foods and results high hydration capacity when rehydration capacity was determined. Mushrooms processed from oven drying did not showed difference in rehydration capacity even pretreated with ascorbate and osmotic solution in the study, however, mushrooms processed in pickling and oven drying were different in rehydration capacity within the same pretreatment used.

On the other hand, the rehydration capacity of pickled mushrooms pretreated with ascorbate solution was higher than that of pickled mushroom pretreated with osmotic solution. The general trends found in the study, the rehydration capacity of dried mushrooms were higher than that of pickled mushrooms pretreated with both ascorbate and osmotic solutions.

Moreover as it is presented in Table 4, the rehydration capacity of mushrooms increased as rehydration temperature increased for both pickled and oven dried sample. However, oven dried samples obtained high rehydration capacity for rehydration temperature allowed 30^{o}C and 60 ^{o}C, respectively.

Soluble solid determination during rehydration

As the data presented in Table 4 shows, the soluble solid content of pickled and dried mushroom slices obtained in this study was found to be between 1.14 ^{o}Brix maximum and 0.85 ^{o}Brix minimum, respectively. The interaction effect of pretreatment and processing method significantly ($p<0.05$) affected dry matter content of mushrooms.

The soluble solid content of dried mushroom subjected to both osmotic and ascorbate pretreatments were the highest of all, while the lowest soluble solid content were obtained in pickled mushroom prepared from osmotic solution. The soluble solid content of mushrooms pretreated with ascorbate solutions obtained the maximum value than that of mushrooms pretreated with osmotic solution for the same processing methods used. Oven dried mushrooms pretreated with ascorbate scored the highest soluble solid value and the least soluble solid content was obtained from pickled mushrooms pretreated with osmotic solution. The interaction effect of ascorbate pretreatment with pickling and oven drying increased the soluble solid content of mushrooms than osmotic pretreatment. This is positively related with the dry matter content of samples. Mushrooms with high dry matter content obtained lower soluble solid and the reverse.

Sensory evaluation

The data from the study indicated that there was a relationship between the mushroom quality parameters and sensory evaluation results. The prepared mushrooms had good flavour characteristics, attractive colour, texture and fairly overall acceptability.

The highest colour acceptance mean score (6.75) was obtained from mushroom pickle pretreated with

ascorbate solution. The lowest colour acceptance score (5.21) was given to oven dried mushroom pre treated with ascorbate solution. However, colour acceptances of mushrooms were good for oven dried and pickled mushrooms pretreated with osmotic solution. Similarly, processing method and pretreatments showed clear difference in colour acceptance and the highest score was found in osmotic pretreated mushrooms, due to osmotic solutions have good properties to regulate colour and did not affected the primary colour of mushrooms.

The flavour strength of ascorbate pretreated pickle mushroom increased. On the other hand, the highest flavour level mean score (6.61) was obtained from pickled mushrooms pretreated from ascorbate solution, while the lowest flavour (5.21) was given to oven dried mushrooms pretreated from ascorbate solution. Generally, mushroom samples pretreated with osmotic solution subjected with pickling and oven drying showed higher flavour score than mushroom samples pretreated with ascorbate solution (Resurreccion and Anna, 1998).

The texture preference of osmotic pretreated mushrooms prepared from pickling and oven drying showed the higher score than that of mushrooms pretreated with ascorbate solution. Finally, overall acceptability increased when mushrooms pretreated with ascorbate solution and particularly processed by pickling. The overall acceptability of pickled mushroom sample pretreated with ascorbate and osmotic solutions were higher than that of oven dried mushroom samples.

Conclusion

The study generally investigated the effect of pretreatments combined with processing to better improve the shelf life and quality of perishable produce such as mushrooms. Ascorbate solution pretreatment followed by pickling resulted in the best chemical composition and sensory properties of mushroom samples. Ascorbate treatments combined with pickling are advantageous in terms of mushroom quality as compared to oven drying methods and osmotic pretreatments. In addition, unlike osmotic pretreatments, the mushrooms being pretreated in ascorbate maintained their nutritional composition, acidity and physical qualities. The sensory evaluation results of the pickled mushroom products were well accepted and obtained better colour, flavour and as well as overall acceptability than that of oven dried products. Therefore, application of appropriate pretreatments and non complicated processing methods are needed to solve the perishability problem of mushrooms so as to prolong the potential of mushroom cultivation in the countries like Ethiopia where mushroom cultivation is very low.

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Table 1. The interaction effect of pretreatments and processing methods on chemical composition of pickled and dried mushroom

Variables		Proximate Results		
Pretreatments	Processing methods	Moisture Content (%)	Crude Fibre (% db)	Crude Fat (% db)
Ascorbate solution	Pickling	68.57	9.41	2.19
	oven drying	6.70	9.04	1.94
Osmotic solution	Pickling	79.58	10.14	2.24
	oven drying	7.99	10.21	2.14
Coefficients of Variations		2.22	0.55	1.19

Table 2. The interaction effect of pretreatments and processing methods on chemical composition of pickled and dried mushroom

Variables		Proximate analysis results		
		Crude Protein (% db)	Carbohydrate (% db)	Total Ash (%db)
Pretreatments	Processing methods			
Ascorbate solution	Pickling	25.99	43.08	15.77
	Oven drying	24.95	45.18	12.2
Osmotic solution	Pickling	27.14	59.99	2.22
	Oven drying	24.99	43.64	2.12
Coefficients of Variations		1.11	1.63	0.67

Table 3. The interaction effect of pretreatments and processing methods on dry natter content and rehydration capacity of mushrooms.

Variables		Dry matter and rehydration	
Pretreatments	Processing methods	Dry Matter (% db)	Rehydration capacity
Ascorbate solution	Pickling	91.45	0.04
	Oven drying	93.28	0.09
Osmotic solution	Pickling	90.42	0.2
	Oven drying	92.02	0.09
Coefficients of Variations		0.21	0.24

Table 4. The interaction effect of pretreatments, processing methods and rehydration temperature on soluble solid content and rehydration capacities of mushroom

		Soluble solid and rehydration capacity		
		SS(^{0}B)	Rehydration capacity	
Pretreatments	Processing methods		30^{o}C	60^{o}C
Ascorbate solution	Pickling	0.99	0.57	0.89
	Oven drying	1.14	1.23	1.83
Osmotic solution	Pickling	0.85	0.46	1.03
	Oven drying	0.95	2.01	2.75
Coefficients of Variations		0.43	0.39	0.37

Table 5. The interaction effect of pretreatments and processing methods on sensory attributes of mushroom Samples (n = 53)

		Sensory parameters			
Pretreatments	Processing methods	Colour*	Flavour**	Texture***	Overall acceptability
Ascorbate solution	Pickling	6.75	6.61	6.03	6.65
	Oven drying	5.21	5.98	5.39	5.76
Osmotic solution	Pickling	6.24	6.25	6.65	6.36
	Oven drying	6.36	6.17	6.10	5.88
CV		2.21	2.59	2.11	2.42

* Light grey for pickled and Light brown for oven dried, ** Spicy for pickled and Aromatic for oven dried, *** Rubbery for pickled and Fibrous for oven dried mushrooms

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