Effects of Rehydration Ratio on the Quality of Auricularia auricula-judae Mushroom

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Abstract This Study aimed to investigate the rehydration ratio, temperatures, times, amount of leaching of polysaccharide content and storage (CFU) of A. auricula-judae mushroom. Five rehydration temperatures (25, 40, 60, 80 and 100°C) and the water immersion time (10, 20, 30, 40, 50, 60 minutes) were used. The highest rehydration ratio 9.53% as observed in the soaking temperature of 100°C whereas the lower rehydration ratio 5.65% obtained at 25°C correspondingly. Whereas the polysaccharide content result revealed that maximum loss found 12.62% soaking temperature of 100°C for 60min while a minimal loss, 4.23% at soaking temperature of 60°C for 30 min. Monosaccharide composition was analyzed via gas chromatography it showed the polysaccharide composed of glucose, galactose, rhamnose, mannose and arabinose. Highest overall viable count of bacteria ranges from 2.5 x10⁵ cfu/g to 6.75 x10⁷ cfu/g. However, the effect of time and temperature on the rehydration found to be significant (P>0.05).

Keywords: rehydration ratio, polysaccharides content, monosaccharide, bacterial count, quality, storage

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1. Introduction

Auricularia Auricula (generally called black woody ear or tree ear), a precious macrofungus, has a reputation as being a health promoting food in China. The A. auriculajudae is a traditional fungi food and found throughout the year in temperate regions worldwide. This mushroom native to Asia and some Pacific islands with humid climates, according to the Mycological Society of San Francisco. A. auricula-judae is an edible mushroom and often used in Asian cooking [1].

Mushrooms have been used since earliest times not just as foods or food flavouring materials, although for medicinal and functional purposes. The nutrients can be obtained moderately economically from A. auricula-judae are very important for human body maintenance. A. auricula-judae generally purchased in dried form, prior to use it required the soaking in water for a short period of time and it puff up to several times toward its normal size. Many dehydrated products commonly used in place of fresh foods owing to several advantages such as convenience in shipping, storage, processing preparation and use. Dehydrated products need to be rehydrated before consumption as further processing ([2,3,4]).

Rehydration is a complicated process intended at the restoration of raw material properties, is the replacement of water in dehydrated foods. Rehydration can be considered as a remedial measure of the damage to the material caused by the drying process. It is generally accepted that rehydration is directly related to the degree of cellular and structural damage caused to the food (5-10). Rehydration medium and temperature have been studied by ([2,6,11]). Rehydration is a process of moistening dry material [13] and is generally carried out by soaking the dry material in large amounts of water, even though, instead of this, some authors have used air with high relative humidity, either statically or in a drying chamber with air circulation [14]. Three major processes take place at the same time during rehydration the imbibitions of water into the dried material and the swelling and the leaching of soluble solid [15]. A.auricula-judae is rich in polysaccharides, which contain lots of beneficial effects on health. polysaccharides are important pharmaceutical components which give advantages on human health such as anti-inflammatory effectively, demonstrate strong immunomodulatory and antitumoral activities and pharmacological properties [16]. Pharmacologically the polysaccharides have been used as an anticoagulant and to lower cholesterol [17]. Fungal polysaccharides have been identified as promoting human health, polysaccharides is a

key source of biological activity and consideration to avoid cancer for medicinal use of Auricularia auricula.

Dried foods are used in all sorts of industrial food products, generally dehydrated products are rehydrated for final use in many process industries. Consequently, it is important to know rehydration characteristics and leaching of nutrient (polysaccharide) influenced by processing conditions. Therefore, this study was conducted to assess the rehydration characteristics of auricula-judae mushroom at five temperatures (25, 40, 60, 80 and 100°C) on different water immersion time (10, 20, 30, 40, 50 and 60 minutes) to examine the leaching of polysaccharide during soaking. The rehydrated samples were stored at ambient temperature $30 \pm 2^{\circ}C$ to evaluate the shelf life and colony forming count (CFU). While determination of the monosaccharide composition, polysaccharide sample was freeze dried and analysis using a GC method.

2. Materials and Methods

2.1. Chemical and Standards

A. auricula-judae mushroom was obtained from (Hebei Province, China.). All reagents used were of analytical grade. Standard reagents including D-mannose (Man), Lrhamnose (Rha), D-ribose (Rib), D-galactose (Gala), Dxylose (Xyl), D-arabinose (Ara), L-fructose (Fuc), and Dglucose (Glu), were purchased from Sigma–Aldrich (USA). Hydroxylamine hydrochloride, acetic anhydride, sodium hydroxide (50%), inositol, pyridine, trifluoroacetic acid (TFA), methanol, hydrochloric acid and acetic acid were obtained from the sinopharm chemical reagent Co. Ltd (Shanghai, China).

2.2. Instrumentation

The following instruments were occupied: rotary evaporator model RE-2000A (Yarong Bio-instrument Shanghai, China) water bath model KD-98-IIA Tianjin Taisite Instrument Co., Ltd. spectrophotometer (ZW0310072703 Shanghai, China), Autoclave (Model-YX 280 A, Shanghai, China, gas chromatograph model 6890 (Agilent Technologies, USA) fitted with a HP-5 Silica capillary column (30 m \times 0.32 X 0.5 um) and a flame ionization detector (FID).

2.3. Process of Rehydration

Different rehydration times and temperature were used to obtain the best time. Rehydration experiments were carried out in distilled water at 25, 40, 60, 80 and 100°C (± 0.2 °C). A. auricula-judae pieces used as a sample of 2 g for rehydration by immersion in a waterproof container using a solid/liquid ratio of 1:50 of distilled water, equilibrated to the rehydration temperature in a water bath. The samples were then allowed to rehydrate for various lengths of time treated, i.e. (10, 20, 30, 40, 50, and 60min) samples were removed at regular intervals and weighed. At the end of rehydration time, samples surface water was removed smoothly with tissue paper. The rehydration ratio was expressed by the following formula. Sample was weight after and before keeping it in the hot water bath.

 $Rehydration \ ratio = \frac{weight \ of \ rehydrated \ material}{weight \ of \ dehydrated \ material}$

2.4. Preparation of Blank Solution

To 1ml of distilled water added 1ml of 5% phenol followed by 5ml of concentrated H_2SO_4 .

2.5. Preparation of Standard Solution

A stock solution 100μ g/ml of glucose was prepared in distilled water. 1ml of 5% phenol solution was added to 1 ml of sugar solution followed by 5ml of concentrated H₂SO₄. The absorbance was measured at 490 nm against the blank.

2.6. Determination of Total Polysaccharide

The total polysaccharide was determined by the phenolsulfuric acid method according to the [18] 1 mL of sample solution and I mL of aqueous solution of phenol in test tube. A 5 mL of concentrated sulfuric acid is added rapidly to the mixture. Test tubes allowed to stand for 10 minutes and vortexed for 30s and kept in a water bath for 20 minutes at 35°C for color development. Concentration was determined via a spectrophotometer at absorption of 490 nm using the spectrophotometer (ZW0310072703 Shanghai, China) using the method of [19]. The experiment was carried out in triplicate. Standard D-Glucan was used to draw the standard curve equation is y=0.0142x+0.075, $R^2=0.997$.

Polysaccharides loss was calculated by the following formula:

 $Polysaccharides Loss \\ = \frac{Dilution \times Total Volume \times 0.9}{Weight of Sample} \times 100\%$

2.7. Analysis of Monosaccharide Compositions

Freeze dried samples used for the analysis of monosaccharide composition; A. auricula-judae (10mg) was hydrolyzed with 2.0 M TFA (5 ml) at 100°C for 4 h in sealed plastic tube [20]. Hydrolysate was evaporated to dryness using 2 ml methanol 3-5 time under reduced pressure at 40°C, in a rotary evaporator (Model RE-2000A Yarong Bio-instrument Shanghai, China). Pyridine 0.5 ml, 10.0 mg hydroxylamine hydrochloride and 2.0 mg inositol hexaacetate (as internal reference) were added, mixture stand to react in a water bath (model KD-98-IIA Tianjin Taisite Instrument Co., Ltd) at 90°C for 30 min. Then tubes were cooled to room temperature, after cooling 1ml of acetic anhydride was added and mixed totally by vortexing and the reaction was continued at 90°C for 30 min. After incubation, the tubes were cooled to room temperature and 10 ml chloroform was added to the solution. The lower layer (organic layer) was collected and evaporated to dryness under reduced pressure at 40°C, using a rotary evaporator then dissolved in 500 µL of chloroform for use. A 1-3 µl of the chloroform solution was injected into the GC. Standards of monosaccharide include 10 mg each of Man, Rha, Rib, Gala, Xyl, Ara, Fuc and Glu was prepared and treated in the same way. The procedure was performed in the following conditionsinjection temperature: 270°C, detector temperature: 250°C, column temperature programmed: 150° C in the beginning, maintained for 5 min, then increasing to 190°C at 10/min and finally keeping for 5 min at 210°C at 2/min and fitted

with a HP-5 Silica capillary column (30 m \times 0.32 X 0.5 um.) High-purity helium was used as the carrier gas and maintained at 1.2 mL/min.

2.8. Preparation of Medium, Inoculation and Incubation

The nutrient agar medium used for microbial study, the media were prepared according to the manufacturer's instruction and used for enumeration of total viable bacteria. Prior to the sterilization pH of the medium was adjusted at 7.0. Media and all required material were sterilized by autoclave at 121°C (Model-YX 280 A, Shanghai China) for 30 minutes. 25g of A. auricula-judae samples were aseptically removed from the glass beaker and mixed with 180 mL of NaCl solution and dilution were prepared of 10^{-1} to 10^{-10} . The analysis was accomplished according to the method of APHA [21] Sterilized petri dishes were used and Inoculated with 0.10 ml of dilution on nutrient agar plates and uniformly spread by glass rod using Laminar Air Flow Cabinet (Model SW-EF-2 FD, Shanghai China). Inoculated plates were incubated at 37°C for 24-48 hours. After incubation, colonies were counted by using colony counter and total coliform was calculated. The colonies were characterized morphologically via Gram's stain according to the method described by [22]. A small colony was picked up from nutrient agar plates with a bacteriological loop, smeared on a glass slide with a drop of distilled water and fixed by gentle heating. Crystal violate die was then applied to slide for one minute followed by washing with running water. Two drops of Gram's Iodine then added for one minute and next washed with running water. Acetone was then poured (acts as decolorizer) for few a seconds, followed by washing with water. Following safranin stain was added as counter stain and allowed to stain for one to two minutes. The slides were then washed with water, dried in the air and examined under a compound microscope (Model No 13395 H2X Leica Microsystems) with the high power objective (100X) using immersion oil.

2.9. Statistical Analysis

Data were calculated Significance differences were found out using analysis of variance (ANOVA) Statistical significance was established at p < 0.05, Using the software package SPSS (IBM Statistics version 20).

3. Result and Discussion

3.1. Rehydration Ratio

The rehydration ratio of the A. auricula is shown in Figure 1. It was observed that the rehydration ratio increased with enhanced in the temperature and time of soaking. Highest soaking temperature of 100° C showed the increased in rehydration ratio was higher than at 40° C, 60° C respectively. This is in agreement with the investigation of others researcher when an increased in bath temperature frequently gives a higher rehydration ratio for dried food products ([13,23,24,25]). It was examined that the higher the temperature, the higher the rehydration ratio this may possibly be due to the fact that the high soaking water temperature resulted in loss of

elastic properties of cell tissues moderately than causing an opening up of the pores, which invariably reduced the rate of rehydration. The result are agreement with [26], showing that increasing drying temperature leads to the increase of water liberation rate, then promoting important structure deformations in the biological material. Finding of the others research stated that the rehydration ratio used to express the rehydration of the dehydrated food such as carrots, mushrooms, pears, potatoes, and coriander leaves ([27,28,29,30,31]) As the temperature of the soaking water increased, rehydration became faster this may be due to the rapid absorption of water as a consequence of a more open structure which favored rapid rehydration A. auricula-judae. This is similar to the observation of [32] that reconstitutes ability of food products. Rehydration characteristics was found that there is a dissimilarity between the time and temperature of A. auricula-judae temperature showed an obvious effect on rehydration (Figure 1).



Figure 1. Rehydration ratio of Auricularia auricular Mushroom

3.2. Polysaccharides Loss

The polysaccharide contents of rehydrated samples of A. auricula-judae are indicated in Figure 2. The residual quantity of polysaccharide leached in the rehydrated samples increased with an increased in soaking water temperature. Polysaccharide content in larger quantity was leached into the soaking water at high temperature of 80°C and 100°C respectively (Figure 2). Experiment result showed that a maximum polysaccharides loss found 12.62% at 100°C soaking for 60min was higher than 4.23% at 60°C soaking for 30 min correspondingly. A significant increase in polysaccharide content was observed within the differential temperature. The polysaccharides loss was different from each temperature and time throughout the rehydration, numerous changes can occur at extensive soaking times, rehydration in carrot cubes found higher loss of solids at the temperatures of 95°C, it was maybe due to the loss of integrity of the material and damaged the structure which influenced water mass flow [33]. Results are further in agreements with the [34,35,36], high temperature generates a loss of solids or diffusion of soluble components. Carrot rehydration generates several changes as the increased in

the soaking temperature into the dried material, enhanced the swelling and leaching of soluble solid from dried foods ([7,37]). Several other studies illustrated water uptake and solids dissolution occurred at the same time during the rehydration of food products as dried apple slices [38], dried chickpea [34], puffed breakfast cereals [39]. Their study observed that the amount of solids discharge was significant even for short periods of time, leaching of solids during rehydration of hot air and freeze dried particulate carrots. ([3,34]) reported that rehydration of chickpea at low temperature of 25°C effect loss of solids.



Figure 2. Polysaccharideloss of Auricularia Auricula Mushroom

3.3. Storage of Rehydrated A. auricula-judae and COLONY FORMING UNIT (CFU)



Figure 3. Storage life Auricularia Auricula Mushroom

Storage life of rehydrated samples of A. auricula-judae are presented in Figure 3. Rehydration samples of different temperature soaking were kept in glass containers and sealed with polyethylene and stored at ambient temperature $30^{\circ}C \pm 2^{\circ}C$. A. auricula-judae samples affected by bacteria during storage and produces off flavor, shelf life ranges from 4 to 7 days respectively at the different temperature and time soaking. Mushrooms have a short shelf life of 3–4 days compared to most vegetables at ambient temperatures, due to mushroom don't have cuticle to protect them from physical or microbial attack or water loss [36]. Analysis of Variance indicates that there were a significant effect of temperatures on storage p- <0.005.

3.4. Morphology and Bacterial Count

Colony forming units of rehydrated A. auricula-judae are presented in Table 1. The total bacterial count of A. auricula-judae was counted after 48 hours that ranged from 2.5×10^5 (cfu/g) to 6.75×10^7 (cfu/g) respectively. The CFU count of A. auricula-judae rehydrated on different temperature of soaking 40°C, 60°C and 80°C were ranged 3.2×10^4 to $1.9 \times 10^4 \text{ cfu/g}$, 6.45×10^{6} from cfu/g correspondingly. Number of colonies that appeared on the different plates was counted by colony counter and expressed as colony forming units per gram (cfu/g). Bacterial colonies were differentiated and recognized as described by [40]. Morphology of the colony was identified on the basis of morphological demonstration i.e. color, shape, size, opacity, degree of growth and consistency. It was observed that the most of the medium plates were found to be light yellow in color, circular in shape, small in size and moderate in growth. The results of Gram's staining showed that the two bacteria isolated from A. auricula-judae were gram positive, bacillus and staphylococcus. Research findings are in agreements with the finding of [41] he described that A. auricula-judae were affected by three kinds, Citrobacter, staphylococcus and bacillus species during storage.

Table 1. Colony-forming units of affected A. auricula-judae

Temperature	Colony-Forming Units (CFU/g)
25°C	2.5 x10 ⁵
40°C	3.2×10^4
60°C	1.95 x10 ⁴
80°C	6.45 x10 ⁶
100°C	6.75 x10 ⁷

3.5. GC Chromatography

Figure 4, showed the GC results of A. auricula-judae sample and the GC chromatogram of Fructose, rahmnose, xylose, arabinose, mannose, glucose and galactose. Whereas as the Figure 4 showed monosaccharide standards Peaks: (1) fructose (2) rahmnose (3) xylose (4) arabinose (5) mannose (6) glucose and (7) galactose. The peaks for all monosaccharides were sharp and symmetrical in the chromatogram. The retention times of F-Fructose, Rham (rhamnose), Xyl (xylose), Ara (arabinos), Man (mannose), Glu (glucose), and Gal. (galactose), were 2.959, 10.709, 11.533, 11.173, 16.840 17.115 and 18.089 min, respectively. The investigation of the results from GC showed that the predominant monosaccharide in A. auricula-judae were galactose, glucose and mannose. The use of a 30 m×0.32 mm capillary column demonstrate in good resolution with a

run time of 34 min. The regression equation and correlation coefficient (R^2) of each temperature and all the standards were determined with an SPSS statistical software system. The regression equations for different

temperatures 25°C, 40°C, 60°C, 80°C and 100°C were y=0.748X0.1956, y=0.414X0.1654, y=0.758X 0.2626 y= 0.916X0.121 y= 0.809 X0.2154 y=0.962 X 0.1725 respectively and R^2 0.963.



Figure 4. GC chromatogram of monosaccharides of rehydration of sample on different soaking temperatures from A. auricula mushroom (A) rehydration at 25°C, (B) rehydration at 40°C, (C) rehydration at 60°C (D) rehydration at 80°C (E) rehydration at 100°C

4. Conclusions

Rehydration ratio and polysaccharide content were higher during treatment at high soaking temperatures. Higher temperature showed a soluble component was leached during processing. Rehydration on the soaking temperature of 60°C and 40min were found to be good. The rehydration quality during storage was also not stable and affected by bacteria. In order to understand the effect of temperature on rehydration quality further study required, therefore it is most important to carry further study on a rehydration experiment for assembles efficient method for rehydration of mushroom.



Figure 5. Monosaccharide standards Peaks: (1) fructose (2) rahmnose (3) xylose (4) arabinose (5) mannose (6) glucose and (7) galactose

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References

- William Peterman Benefits of black fungus http://www.livestorng.com. 29389/2010.
- [2] Nayak CA, Suguna K, Rastogi NK.Combined Effect of Gamma-Irradiation and Osmotic Treatment on Mass Transfer During Rehydration of Carrots. *Journal of Food Engineering*; 134-142, 2006.
- [3] Marabi, A., C. Dilak, J. Shah and I.S. Saguy. Kinetics of solid leaching during rehydration of particulate dry vegetables. *Journal* of Food Science.69: 91-96. 2004.
- [4] Jambrak AR, Mason TJ, Paniwnyk L, Lelas V. Accelerated Drying of Button Mushrooms, Brussels Sprouts and Cauliflower by Applying Power Ultrasound and Its rehydration Properties. *Journal of Food Engineering*; 81(1) 88-97, 2007.
- [5] Bilbao-Sainz et al "Hydration kinetics of dried apple as affected by drying condion *Journal of Food Engineering*. 68, 369-376. 2005.
- [6] Krokida MK, Marinos-Kouris D. Rehydration Kinetics of Dehydrated Products. *Journal of Food Engineering*; 57(1) 1-7. 2003.
- [7] Krokida M.K., Philippopoulos C. Rehydration of dehydrated foods. Drying Technology 23, 799-830. 2005
- [8] Lewicki, P. Some remarks on rehydration of dried foods. *Journal of Food Engineering* 72, 16-23. 2006.
- [9] Krokida M K, T Sami E, Maroulis ZB Kinetics on color changes during drying of some fruits and vegetables. *Drying Technology*.16 (3-5), 67-685. 1998.
- [10] Sacilik, K., Elicin, A.K.. The thin layer drying characteristics of organic apple slices. *Journal of Food Engineering* 73. 281-289. 2006.
- [11] Sanju'an N, Simal S, Bon J, Mulet A. Modelling of broccoli teems rehydration process. *Journal of Food Engineering*. 42: 27-31. 1999.
- [12] Krokida MK, Marolis ZB. Structural Properties of Dehydrated Products During Rehydration. *Journal of Food Science and Technology*; 36(5) 529-538, 2001.
- [13] Femenia, A., Bestard, M.J., Sanjuan, N., Roselló, C. and Mulet, A. Effect of rehydration temperature on cell wall components of

broccoli (Brassica oleraceaL. var. italica) plant tissues. *Journal of Food Engineering*. 46, 157-163. 2000.

- [14] García-Pascual P, Sanjuán N, Bon J, Carreres JE, Mulet A. Rehydration Process of Boletus edulis Mushroom: Characteristics and Modelling. *Journal of the Science of Food and Agriculture*; 85(8) 1397-1404, 2005.
- [15] Moreira R, Chenlo F, Chaguri L, Fernandes C. Water Absorption, Texture, and Color Kinetics of Air-Dried Chestnuts During Rehydration. *Journal of Food Engineering*; 86(4) 584-594, 2008.
- [16] Kala P. Chemical composition and nutritional value of European species of wild growing mushrooms: A review. *Food Chemistry*. 113: 9-16. 2009.
- [17] Yoon S J, Yu M A, Pyun Y R, Hwang J K, Chu D C. The nontoxic mushroom Auricularia auricula contains a polysaccharide with anticoagulant activity mediated by antithrombin: Thrombosis Res; 112(3): 151-158. 2003
- [18] Liu GQ, Wang XL. Selection of a culture medium for reducing costs and enhancing both biomass and intracellular polysaccharide production by Agaricus blazei AB. *Journal of Food Technology Biotechnology*. 47: 210-214. 2009.
- [19] Foster D S, and Cornella T S. Colorimetric Method of Analysis Vol.8 A, D.Van Nostrand Company Inc. *Princeton. New Jersey*. New York: 1961: 162. 2005.
- [20] Yang B, Jiang YM, Zhao MM, Chen F, Wang R, Chen YL, Zhang DD. Structural characterization of polysaccharides purified from longan (Dimocarpus longan Lour.) Fruit pericarp. *Food Chemistry*. 115: 609-614. 2009.
- [21] APHA Compendium of methods for the microbiological examination of foods. Frances, P.D. and Keith, I., eds., Washington DC: APHA (2001).
- [22] Merchant IA and Packer RA. Veterinary Bacteriology and Virology. 7th edn., *The Iowa State University Press*, Ames, Iowa, USA. 211-305. 1969.
- [23] Maharaj, V. and Sankat, C.K. The rehydration characteristics and quality of dehydrated dasheen leaves. *Canadian Agricultural*. *Engineering*, 42(2), 81-85. 2000.
- [24] Mastrocola, D., Dalla rosa, M. and Massini, R.. Freeze dried strawberries rehydrated in sugar solutions: Mass transfers and characteristics of final products. Food Research International. 30, 359-364, 1997.
- [25] Rastogi, N.K., Angersbach, A., Niranjan, K. and Knorr, D. Rehydration kinetics of high-pressure pretreated and osmotically dehydrated pineapple. *Journal of Food Science*. 65, 838–841. 2000
- [26] Foust, A.S.; Wenzel, L.A.; Clump, C.W.; Maus, L.; Andersen, L.B. principle of unit operation. Publisher AS, *Rio de Janeiro, 2 edition*, 670P. 1982.
- [27] Wang J, Xi YS. Drying Characteristics and Drying Quality of Carrot Using a Two-Stage Microwave Process. *Journal of Food Engineering*; 68(4) 505-511, 2005.
- [28] Giri SK, Prasad S. Drying Kinetics and Rehydration Characteristics of Micrwave Vacuum and Convective Hot-Air Dried Mushrooms. *Journal of Food Engineering*; 78 (2) 512-521, 2007
- [29] Komes D, Lovrić T, Kovačević-Ganić K. Aroma of Dehydrated Pear Products. LWT; Food Science and Technology, 40(9) 1578-1586, 2007.
- [30] McMinn WAM, Magee TRA. Physical Characteristics of Dehydrated Potatoes–Part II. *Journal of Food Engineering*; 49-55, 1997.
- [31] Kaur P, Kumar A, Arora S, Ghuman BS. Quality of Dried Coriander Leaves as Affected by Pretreatments and Method of Drying. *European Food Research and Technology*; 223(2) 189-194, 2006.
- [32] Brennan JG, Butters JR, Cowell ND, Lilly AEV. Dehydration in Food Engineering Operations. London: *Elsevier Applied Science*.3rd Edition, Applied Science, London. 1990.
- [33] Zielinska M., Markowski M. Air drying characteristics and moisture diffusivity of carrots. *Chemical Engineering and Processing* 49. 212-218. 2010.
- [34] Chenoll, C., Betoret, N. & Fito, P. Analysis of chickpea (var. "Blanco Lechoso") rehydration: part I. Physicochemical and texture analysis. *Journal of Food Engineering* 95, 352-35. 2009
- [35] Lee, K. T., Farid, M., & Nguang, S.K. The mathematical modelling of the rehydration characteristics of fruits *Journal of Food Engineering* 72, 16-23. 2006.
- [36] Martine B., Gaëlle L.P., and Ronan G., Post-harvest treatment with citric acid or hydrogen peroxide to extend the shelf life of

fresh sliced mushrooms. LWT - Food Science and Technology., 33, 285-289. 2000

- [37] Marabi A, Thieme U, Jacobson M, Saguy IS. Influence of Drying Method and Rehydration Time on Sensory Evaluation of Rehydrated Carrot Particulates. *Journal of Food Engineering*;72(3) 211-217, 2006.
- [38] Atares, L., Chiralt, A. & Gonzalez-Martinez, C. Effect of the impregnated solute on air drying and rehydration of apple slices (ct. Granny Smith). *Journal of Food Engineering*, 91, 305-310. 2009.
- [39] Machado, M. D., Oliveira, F. A. R., Gekas, V., & Singh, R. P. Kinetics of moisture uptake and soluble solids loss by puffed breakfast cereals immersed in water. *International Journal of Food Science and Technology*, 33(3), 225-237. 1998.
- [40] Cowan S. T. Cowans and Steels manual for the identification of medical bacteria, 2 edition, *Cambridge University Press*, England 1985.
- [41] Okechukwu R.I, Okereke J. N., Onyedineke N. E. and Obi R. K Microbial and nutritional qualities of mushroom Asian Journal of experimental and biology science. Vol 2(4) 746-749. 2011.