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Influence of Microwave Power on Physico-Chemical Characteristics of Aloe Vera (*barbadensis Miller*) During Microwave Drying

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Abstract : The objective of this present study is to evaluate the influence of different microwave power (180 – 900 W) with an interval of 180 watts on the physico-chemical properties of aloe vera samples during microwave drying. The results showed that,the color of the aloe vera samples were did not affected by the microwave treatment. On the other hand, the rehydration ratio, water holding capacity, shrinkage, total phenolic and flavonoid content was significantly affected by different microwave power level and it was decreased while increasing the microwave power level during drying. From the results, it was found that, the microwave treatment can increase the rate of mass transfer, and enhance the solvent penetration into the cells by disrupting the cellular walls and hydrophobic bonds in the cell membrane, it may lead to a high permeability of samples and decreased the rehydration ratio, water holding capacity, shrinkage, total phenolic and flavonoid content of dried aloe vera samples when compared with fresh materials.
Keywords : Microwave, Drying, Power, Physico-Chemical properties,Total phenol content,Total flavonoid content.

1.Introduction

Aloe vera is a succulent,which belongs to the Liliaceae family. It is one of the 250 known species of aloes, referred by the scientific terms of aloe vera and aloe barbadensis. The semi-tropical plant, aloe vera barbadensis miller from the Lily (Liliaceae) family has a long and illustrious history dating from biblical times. It has been mentioned throughout recorded history and was given a high ranking as an all purpose of herbal plant. Aloe's thick, tapered, spiny leaves grow from a short stalk near ground level. Aloe vera is an herbal plant species with the botanical name of aloe barbadensis miller. Aloe vera is well known for its marvelous medicinal properties. These plants are one of the richest sources of health for human beings comes from nature. It has been grown as Ornamental plant widely in India, it is found in Rajasthan, Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu. There are many products of the plant which is in the treatment of various ilments. It is a shrubby or arborescent, perennial, xerophyti, pea-green color plant belonging to Asphodelaceae (Liliaceae) family. Aloe vera (barbadensis Miller) is grown commercially for the health and moisturizing benefits found inside its leaves. An adult aloe vera plant reaches maturity at 1-2 years and can reach a height of 30 inches with up to 21 leaves. The leaves are green to grey-green in color and thick and fleshy. The fleshy portion of aloe vera leaves contain different phytochemicals and it has been used for medicinal and industrial purposes. The gel contains 97% water content and rest is made of lipids, sterols, glucomannans, amino acids and vitamins. The middle layer consists of a bitter yellow sap and contains glycosides and anthraquinones. The outer thick layer synthesizes carbohydrates and proteins and has protective function.

In the food industry, aloe vera has been utilized as a resource of functional food, especially for the preparation of health food drinks and other beverages, including tea. The aloe gel is used as a moisturizer for skin care, hair care products and a healing agent in cosmetics. Medicinally it is used as antiseptic agents, natural antibiotic agent, calming agent, detoxifier and dilator to increases circulation and blood flow in the skin. It is also used as insect repellent, and a transparent pigment used in miniature painting. The cords and nets are made from the leaf fiber. The amount of aloe vera that finds its application in the pharmaceutical industry in not negligible as far as the manufacturing of topical ointments, gel preparations, tablets and capsules are concerned. Aloe vera gel also finds its application in the cosmetic and toiletry industries, where it is used as a base for the preparation of creams, lotions, soaps, shampoos and facial cleaners. Each aloe vera leaf has three layers; So large scale agricultural production of Aloe Vera is undertaken in several countries such as Australia, Bangladesh, Cuba, Dominican Republic, China, Mexico, Jamaica, Kenya, Tanzania , South Africa and United States of America . But, the shelf life of fleshy portion of aloe vera leaves are very limited. Hence, increasing shelf life of aloe vera pulp without affecting its nutritional and chemical composition is essential to meet out the global needs.

Drying is one of the most traditional methods to preserve food materials for longer storage purposes and its increase the self-life of the end product and it does not affects the nutritional value. It not only reducse the water content, but also affects physical and chemical properties, spoilage, shrinkage, rehydration capacity, and colour[8]. Its recently very popular in microwave drying as compared to other drying techniques, this technique has many advantages as it has higher thermal conductivity, lesser drying time, saves energy, space utilization for sanitation purposes, uniform energy distribution. In recent years microwave drying is popularly an alternate drying method for a wide variety of foods. So far microwave drying method was adapted by several researchers to dry different materials such as Mulberry[3] ,Banana[22]., Plaster of pairs.[32] , Mushroom[35], Carrot[33], Chilli[18], Garlic[36], Apple [15], Spinach [29] , Parsely [40] ,Potato [47], Mushroom[35], Chilli peppers[18], Mint [28], Okra [10].From the literature analysis, the influence of microwave power on physico-chemical properties of aloe vera samples under microwave drying has not been documented. Therefore, this present study has been planned to investigate the effect of different microwave power levels (180 - 900 Watts with an interval of 180 W) on the physico-chemical properties such as color parameters (chroma and hue angle), rehydration ratio, water holding capacity, shrinkage, total phenolic and flavonoid content of aloe vera samples during microwave drying.

2. Materials and Methods

2.1. Materials

Aloe vera leaves are purchased from local vendors, near perundurai, Erode, Tamilnadu, India. Thorns and hard layer present on the surface of aloe vera is removed, washed in tap water to remove surface contaminants and manually peeled off. The aloe vera is cleaned to remove the debris present. For that dematerialized water is used and is decanted. Gravimetric method is generally preferred for determining initial moisture content of aloe vera sample.

2.2. Experimental setup

A programmable multifunctional microwave drier with optimum technology and an output of 900 Watts and with manual microwave power adjustable system (180, 360,540,720 and 900 watts). The frequency 2450 MHz is used for the drying experiment. Electric power to microwave conversion inside microwave oven is done by an important part inside known as the magnetron . The dimensions of the microwave chamber provided is 327 X 370 X 207 mm . A fan is used to regulate the air flow inside chamber by fixing it inside the entire chamber. This fan helps to remove moisture from the drying chamber by passing it through the opening in the oven wall at the top to the outer surface. The oven is also equipped with a glass turn table along with a digital control facility for power adjustment. Five different power levels of 180, 360, 540, 720, 900 watts are taken into consideration for conducting this experiment. A digital balance with an estimated accuracy of 0.01 is fitted on top of the microwave oven which is directly connected with the turn table for weighing the sample without interrupting the drying throughout the project at any instance. The sample is initially placed on a plate on the rotating disk in the microwave oven. The losses of moisture from the sample is noted and recorded at different intervals using Digital balance. As a function of time, three thin layer drying models are used to determine the moisture ratio. Since wide spread cultivation fields are the key source for aloe vera, fresh samples are collected from there.

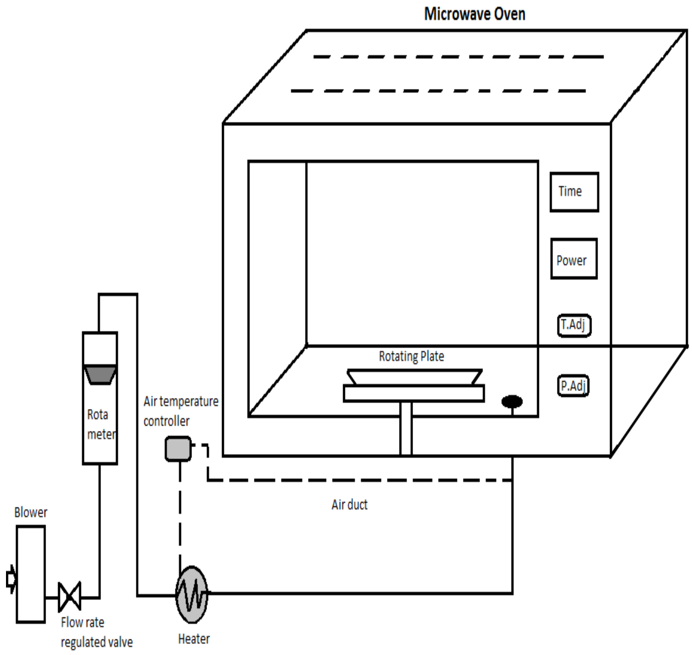

Fig.1. Schematic illustration of the microwave drying set-up

2.3. Determination of colour coordinates

The colour measurements coordinate such as L (brightness or whiteness), a (redness or greenness) ,b (yellowness/blueness) of fresh and dried samples are determined with the help of a Chromameter (Minolta Chroma, CR-400, Japan). The total colour difference (ΔE) and hue angle (H) is attained from the following equations.

$$E = \left((a^* - a_0)^2 + (b^* - b_0)^2 + (L^* - L_0)^2\right)^{0}.5 \quad (1)$$

$$H = tan^{-1}\left(\frac{a}{b}\right) \quad (2)$$

L_0*, a_0*, b_0* – colour parameters of fresh aloe vera samples

2.4. Estimation of rehydration capacity

Rehydration capacity (RC) of dried samples are assessed by taking known amount (W_1) of dried aloe vera samples which is immersed into boiling water for 2 min and then weight of the sample is measured (W_2). The following equation is used to compute the rehydration ratio of the samples

$$RC\,(\%) = \frac{W_2 - W_1}{W_1} \times 100 \quad (3)$$

2.5. Determination of shrinkage ratio

Water displacement method is used to determine the shrinkage ratio (SR) of the sample. The following equation is used to calculate the shrinkage ratio.

$$SR(\%) = \frac{V_1}{V_0} \times 100 \qquad (4)$$

2.6. Estimation of water holding capacity (WHC)

WHC of the samples are estimated by centrifuging the known amount of rehydrated final samples (R_1) at 6500 rpm for 15 minutes, the water is drained by using plastic mesh the weight of the sample is measured (R_2). All measurements are done in triplicates the mean value is calculated and used to find out the WHC of the samples. The WHC is calculated according to the equation 5.

$$WHC(\%) = \frac{R_2 - R_1}{R_1} \times 100 \qquad (5)$$

2.7. Determination of total phenolic content (TPC)

Folin-Ciocalteu method is described by 44 . It is used to determine the TPC of the extracts. 1 ml aliquots of dilute extracts (dilution with distilled water to adjust the absorbance within the calibration limits) is shaken for 1 min with 1.5 ml of the Folin–Ciocalteu reagent and 10 ml of distilled water. After the mixture is shaken, 6 ml of 10 % (w/v) sodium carbonate is added and the mixture is shaken again for 1 min. Finally, the solution is adjusted to 25 ml by adding distilled water. The absorbance are measured at 760 nm using spectrophotometer (Elico SL 244). From the calibration curve of gallic acid, results are calculated and expressed as gallic acid equivalents (mg GAE/g).

2.8. Estimation of total flavonoid content (TFC)

The sample (1 ml) is mixed with distilled water (4 ml) and 5 % (w/v) sodium nitrite solution (0.3 ml). After 5 min, 10 % (w/v) aluminum chloride solution is added in the solution and after 6 min, 2 ml of sodium hydroxide (1 M) solution is added in the sample solutions. The absorbance are measured at 510 nm and TFC is calculated from the standard curve of quercetin and expressed as quercetin equivalents (mg QE/g).

3. Result and Discussion

3.1.Influence of microwave power on color parameters

Determination of color difference (ΔE) and hue angle (H) is one of the best parameters to evaluate the sensory characteristic and expresses the color variation of any samples. Hence in this study, these parameters are evaluated and the results are depicted as in Figure 2.

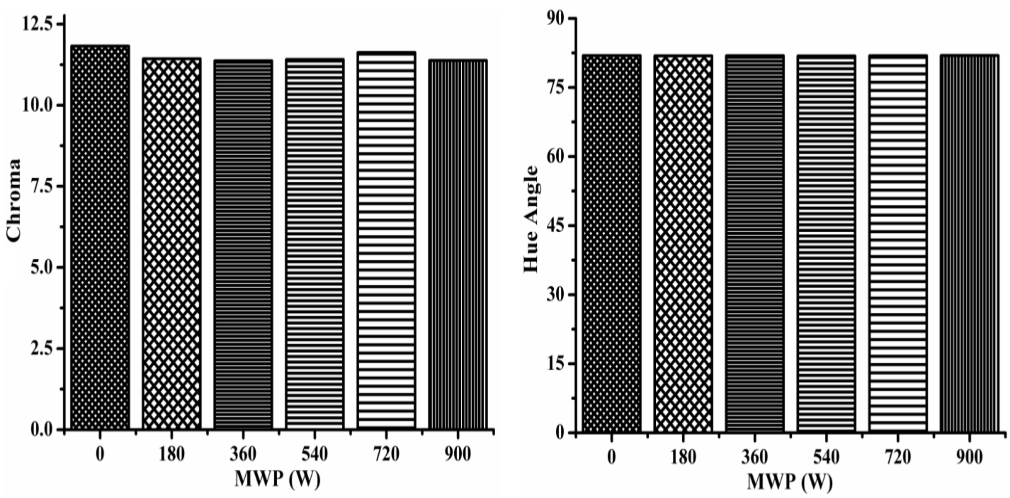

Fig.2. Influence of microwave power on color and Huge angle.

From the results, it is observed that, the color parameters are not significantly differed from control sample. This is due to the fact that, the microwave drying does not cause surface overheating phenomena since it removes moisture on the surface by converting it directly to water vapor and preservation of product color seems good [26] had examined the color change in carrots at different microwave power levels and found that, very small noticeable color change was observed. Similar results were attained by[39] for parsley leaves and coriander leaves[6].

3.2. Influence of microwave power on RR and WHC

Rehydration ratio (RR) is one of the important parameters whether the dried materials could attain the original nature if they are immersed in the water.When the aloe vera is dried at 180 W it shows the have highest RR and WHC and when its dried at higher microwave power level of its shows the lower microwave power (900 W) in (Fig. 3) .This is attributed to the breakdown of the leaves during the drying process at lower microwave power is higher.

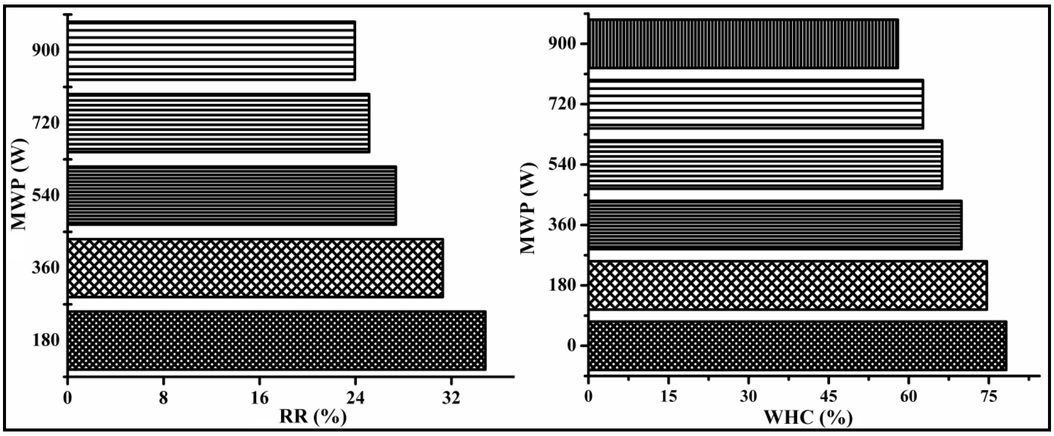

Fig.3.Influence of microwave power on rehydration ratio andwater holding capacity.

In addition to that, the time taken for drying of leaves at 180 W is higher than 900 W and it leads to damage and collapse the cells and tissues. Hence, more space could be created between the tissues and it absorbs more water and enhances the RR and WHC of the samples. The RR and WHC of aloe vera slices are found to have 35 to 25 % respectively under various drying conditions. Similar results on higher values of RR and WHC are reported in the literature by some researchers[31,21].

3.3. Influence of microwave power on shrinkage

Drying is one of the preservation methods and leads to form shrinked materials. Hence in this study, shrinkage of the aloe vera samples during microwave drying is evaluated and presented as shown in figure.4.

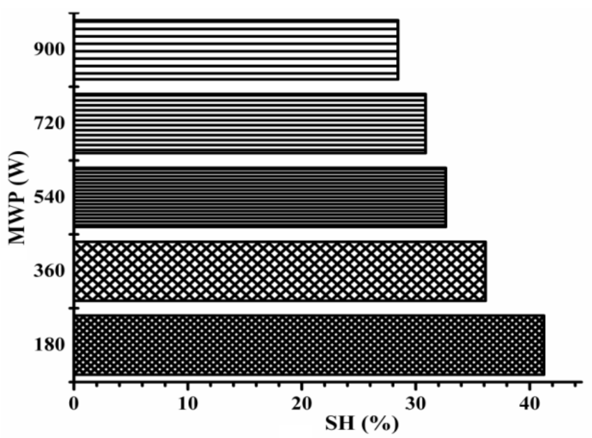

Fig.4.Influence of microwave power on shrinkage

The shrinkage of aloe vera samples are 41.5 to 29 % respectively. Higher shrinkage is found at lower microwave level (180 W) than higher power level (900 W).This is attributed that the fact is, the time taken for attaining equilibrium moisture content of aloe vera sample at higher microwave power level is very low which is due to the fact that the slow sublimation due to extensive heat generation, accelerated removal of water from the tissue. So the cell and tissue damage is minimized and leads to produce low shrinked aloe vera samples.

3.4. Influence of microwave power on TPC and TFC

The total phenolic content (TPC) of aloe vera gel is also shown in Figure 5. A decreasing trend in TPC and TFC is observed in different power levels. TPC and TFC value is changed from the range of 3584.2 to 985.6 mg GAE/100 g d. m. due to different microwave power levels in the samples compared to 896.2 to 249.7 mg QE/100 g d. m. in the control sample.

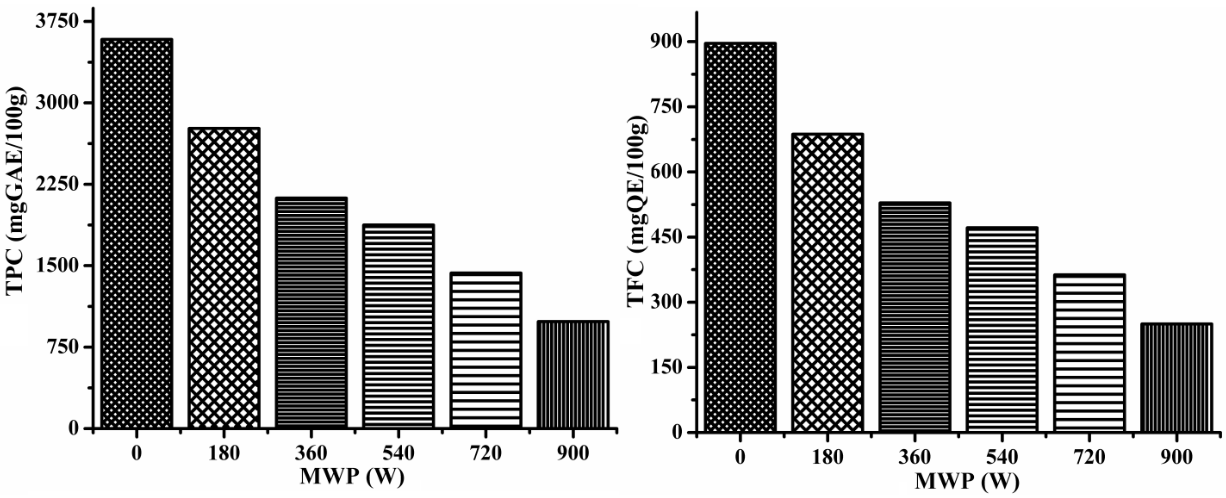

Fig.5. Influence of microwave power on TPC and TFC

The MW treatment increases the permeability of the samples due to the change in the microstructure and it leads to evaporate the volatile compounds which are sensitive to heat. So the TPC and TFC of the dried samples are decreased.

4. Conclusion

Aloe vera samples are subjected to microwave treatment at different power levels (180,360,540,720 and 900 W with an interval of 180 W) and investigated its effect on physico-chemical properties such as color parameters (Chroma and hue angle), rehydration ratio, water holding capacity, shrinkage, total phenolic content and total flavonoid content of fresh and dried aloe vera samples. The samples dried at lower microwave power level (180 W) is shown at a higher rehydration ratio, water holding capacity, shrinkage, total phenolic content and total flavonoid content than samples dried at 900 W of microwave power level. From the results, it is found that, MW treatment does not significantly affect the color parameters of the samples. But it significantly decreases the rehydration ratio, water holding capacity, shrinkage, total phenolic content and total flavonoid content of the dried samples when compared with fresh samples. These results showed that,the microwave drying technique could be used to preserve the aloe vera samples, which would be highly beneficial for the production of a high quality ingredient.

References

1. Ahmed, J.; Ramaswamy, H. S.; hiremath, N. The effect of high pressure treatment rheological characteristics and colour of mango pulp. International Journal of Food Science and Technology,2005. vol. 40, n. 8, p. 885-895.

2. Alagukannan G., Ganesh S., Gopal .S.K,.Characterization and screening of different ecotypes of aloe vera for growth, yield and quality, Internationnal Aloe Science Council Texas: .,2008.302-624.
3. Akpinar, E.K., Mathematical modeling and experimental investigation on sun and solar drying of white mulberry. Ministry Sci.Technol.2008. 22, 1544–1553.
4. Araszkiewicz M; Koziol A; Oskwarek A; Lupinski M .Microwave drying of porous materials. Drying Technology, 2004.22(10), 2331–2341.
5. Arslan, D., Ozcan, M.M.,. Study the effect of sun, oven and microwave drying on quality of onion slices. LWT – Food Sci. Technol. 2010.43, 1121–1127.
6. Ayse Sarimeseli , Microwave drying characteristics of coriander (Coriandrum sativum L.) leaves.Energy Conversion and Management .2011. 52. 1449–1453.
7. Bouraout M; Richard P; Durance T . Microwave and convective drying of potato slices. Journal of Food Process Engineering,1994. 17, 353–363.
8. Chang, X.L., Wang, Ch., Feng, Y. and Liu, Z., Effects of heat treatments on the stabilities of polysaccharides substances and barbaloin in gel juice from Aloe vera Miller. J Food Eng,2006.75(2): 245–251.
9. Crank, J. 1975. The mathematics of diffusion (2nd ed.).Oxford, UK: Clarendon Press. Cronin, K. and Kearney, S. Monte Carlo modeling of a vegetable tray dryer. Journal of Food Engineering.1998. 35(2): 233–250.
10. Dadali, G., Apar, D.K. and Ozbek, B. Estimation of effective moisture diffusivity of okra for microwave drying. Drying Technology.2007. 25(9): 1445-1450. Decareau, R.V. 1992.
11. Darvishi H, Hosainpour A, Nargesi F , Ohmic Heating Behaviour and Electrical Conductivity of Tomato Paste. J Nutr Food Sci .2012.2:167.
12. Doymaz, I. Thin-layer drying behaviour of mint leaves. Journal of Food Engineering .2006.74(3): 370–375.
13. Drouzas, A. E., & Schubert, H. Microwave application in vacuum drying of fruits. Journal of Food Engineering,1996. 28, 203±209.
14. Eshun, K.; He, Q. Aloe vera: A valuable ingredient for the food, pharmaceutical and Cosmetic industries—A review. Crit. Rev. Food Sci. 2004, 44, 91–96.
15. Funebo, T. and Ohlsson, T. Microwave-assisted air dehydration of apple and mushroom. Journal of Food Engineering.1998. 38(3): 353-361.
16. Gupta, P., Ahmet, J., Shivhare, U.S. and Raghavan, G.S.V. Drying characteristics of red chilli. Drying Technology .2002.20 (10): 1975–1987.
17. Handerson SM, Pabis S. Grain drying technology: I. Temperature effect on drying coefficient. J Agr Eng Res ,1961.6(3):169–74.
18. Kaensup W, Chituma S, Wongwises S.Experimental study on drying chilli in a combined microwave vacuum-rotary drum dryer. Dry Technol.2002.20(10):2067–79.
19. Kaleemullah, S. and Kailappan, R., Drying kinetics of red chillies in a rotary dryer. Biosystems Engineering,2005. 92(1): 15–23.
20. Kaya A, Aydın O. An experimental study on drying kinetics of some herbal leaves. Energy Convers Manage.2009.50:118–24.
21. Lakshmanan, R.; Parkinson, J. A.; Piggott, J. R. High-pressure processing and water-holding capacity of fresh and cold-smoked salmon (Salmon salar). LWT-Food Science and Technology, 2007.vol. 40, n. 3, p. 544-551.
22. Maskan, M. . Microwave/air and microwave finish drying of banana. Journal of Food Engineering 2000.44(2): 71–78.
23. Midilli, A., Kucuk, H. and Yapar, Z. A new model for single layer drying. Drying Technology.2002. 20 (7): 1503–1513.
24. Maskan M . Microwave/air and microwave finish drying of banana. Journal of Food Engineering,2000. 44, 71–78.
25. Mousa, N. and Farid, M. Microwave vacuum drying of banana slices. Drying Technology .2002.20: 2055–2066.
26. Mulet, A., Berna, A., & Rosello, S. Drying of carrots. I. Drying models. Drying Technology, 1989.7(3), 537–557.
27. O'Callaghan J R; Menzies D J; Bailey P H . Digital simulation of agricultural dryer performance. Journal of Agricultural Engineering Research,1971. 16, 223–244.

28. Ozbek, B. and Dadali, G. Thin-layer drying characteristics and modelling of mint leaves undergoing microwave treatment. Journal of Food Engineering.2007. 83(4): 541-549.
29. Ozkan, A.I., Akbudak, B. and Akbudak, N. Microwave drying characteristics of spinach. Journal of Food Engineering.2007. 78(2): 577–583.
30. Page G, Factors influencing the maximum rates of air-drying shelled corn in thin layers, 1949.M.S.Thesis,Lafayette,IN: Purdue University .
31. Pandey, P. K.; Ramaswamy, H. S.; ST-Gelais, D.Water-holding capacity and gel strength of rennet curd as affected by high-pressure treatment of milk. Food Research International,2000. vol. 33, n. 8, p. 655 663.
32. Pillai, M.G., Thin layer drying kinetics, characteristics and modeling of plaster of paris. Chem. Eng. Res. Des.2013.
33. Prabhanjan D G; Ramaswamy H S; Raghavan G S V. Microwave assisted convective air drying of thin layer carrots. Journal of Food Engineering.1995. 25, 283–293.
34. Rajasekaran S, Sivagnanam K, Subramanian S. Antioxidant effect of Aloe vera gel extract in streptozotocin-induced diabetes in rats. Pharmacol Rep.2005. 57(1):90-96.
35. Rodrigues R, Lombrana JI, Kamel M, Elvira C. Kinetics and quality study of mushroom drying under microwave and vacuum. Dry Technol.2005.23(9–11):2197–213.
36. Sharma, G.P. and Prasad, S. Drying of garlic (Allium sativum) cloves by microwave–hot air combination. Journal of Food Engineering .2001.50(2): 99–105.
37. Simal, S., Femenía, A., Llull, P. and Roselló, C. Dehydration of aloe vera: simulation of drying curves and evaluation of functional properties. J Food Eng, 43(2).2000.109–114.
38. Souri E, Amin G, Farsam H and Barazandeh Tehrani M. Screening of antioxidant activity and phenolic content of 24 medicinal plant extracts. DARU Journal of Pharmaceutical Sciences, .2008.16 (2):83- 87.
39. Soysal, Y. Microwave drying characteristics of parsley. Biosystems Engineering.2004. 89(2): 167–173.
40. Soysal, Y. and Öztekin, S. Comparison of seven equilibrium moisture content equations for some medicinal and aromatic plants. Journal of Agricultural Engineering Research.2001. 78(1): 57–63.
41. Soysal, Y., Öztekin, S. and Eren, Ö. Microwave drying of parsley: modelling, kinetics, and energy aspects. Biosystems Engineering.2006. 93(4): 403–13.
42. Tulasidas T N; Ratti C; Raghavan G S V. Modelling of microwave drying of grapes. Canadian Agricultural Engineering.1997.39(1), 57–67.
43. Vega-Gálvez, A. et al. Effect of high hydrostatic pressure on functional properties and quality characteristic of aloe vera gel (Aloe barbadensis Miller). Food Chemistry,2011. vol. 129, n. 3, p. 1060 1065.
44. Vega, A., Uribe, E., Lemus, R. and Miranda, M., Hot-air drying characteristcs of Aloe vera (Aloe barbadensis Miller) and influence of temperature on kinetics parameters. Lebensm Wiss Technol.2007. 40(10): 1698–1707.
45. Vega-Gálvez, A. et al. Effect of high hydrostatic pressure pretreatment on drying kinetic, antioxidant activity, firmness and microstructure of Aloe vera (Aloe barbadensis Miller) gel. LWT-Food Science and Technology.2011. vol. 44, n. 2, p. 384-391.
46. Yaldız O; Ertekin C , Thin layer solar drying of some different vegetables. Drying Technology.2001. 19(3), 583–596.
47. Zang M, Tang J, Mujumdar AS, Wang S S . Trends in microwave related drying of fruits and vegetables. Trends Food Sci Technol .2006.17, 524–534.
48. Zheng W, and Wang SY. Antioxidant activity and phenolic compounds in selected herbs. J Agric Food Chem.,2001. 49: 5165 – 5170.

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