ISSN: 0975 -8542

Journal of Global Pharma Technology

Available Online at: www.jgpt.co.in

RESEARCH ARTICLE

Microwave Vacuum Drying Variables Affecting to Processing of Dried *Gomphrena globosa* Floral

Nguyen Phuoc Minh

Faculty of Natural Sciences, Thu Dau Mot University, Binh Duong Province, Vietnam.

Abstract

Microwave vacuum drying is one of the most energy demanding processes. Water evaporation takes place at lower temperatures under vacuum, and hence the product processing temperature can be significantly lower, offering higher product quality. *Gomphrena globosa* is one of the traditional medicinal plants widely distributed in Vietnam. It's considered as a valuable source for pharmaceuticals against various ailments**.** *Gomphrena globosa* L. flowers are a promising source of natural antioxidants**.** Objective of this study focused on the influence of processing parameters such as the microwave power (100, 150, 200, 250, 300 W), system pressure (20, 25, 30, 35, 40 kPa) and drying time (15, 20, 25, 30, 35 min) on shrinkage coefficient, rehydration ratio, color change, total phenolic, flavonoid, betacyanin of dried herbal during the microwave vacuum (MV) drying of *Gomphrena globosa*. At the end of drying process, we also monitored the stability of dried *Gomphrena globosa* flower during 12 months of preservation. Our results showed that the optimal drying process should be conducted at microwave power 250 W at 35 kPa within 30 min to get the best quality of dried *Gomphrena globosa* flower. From this approach, shelf-life of dried *Gomphrena globosa* flower could be last for 12 months without any deterioration. The low temperature and fast mass transfer conferred by vacuum combined with rapid energy transfer by microwave heating generates very rapid, low temperature drying and thus it has the potential to improve energy efficiency and product quality.

Keywords: *Gomphrena globosa, microwave vacuum drying, Shrinkage coefficient, Rehydration ratio, Color change, Total phenolic, Flavonoid, Betacyanin.*

Introduction

Drying is a suitable alternative for postharvest management especially for countries with poorly established low temperature distribution and handling facilities [1]. During drying, the moisture content is reduced to a certain level where microbiological growth will not occur while maintaining high nutrient value. Medicinal and aromatic plants are mainly preserved by air drying. Dried products can be stored for a long time and can be easily blended, powdered or packed for direct use or for further processing in the food or pharmaceutical industry [2].

The use of vacuum in the microwave drying process could be of interest especially for thermo-labile products [3]. In microwave drying, when the material couples with microwave energy, heat is generated within the product through molecular excitation. The critical next step is to immediately remove the water vapour [1].

The use of vacuum lowers the solvent boiling temperature, permitting operation at lower temperatures, directly influencing final product quality [4]. Average temperature during microwave vacuum process is slightly lower than during microwave convective one, which is expected, because during the microwave convective drying additional thermal energy was brought with hot-air [5]. Microwave vacuum drying has been successfully applied to many fruits, vegetables and other heat sensitive foods.

Vacuum-dried materials are characterized by better quality retention of nutrients and volatile aroma [6]. Microwave vacuum drying is a promising, rapid, and efficient dehydration method, which yields improved product appearance and quality compared to conventionally dried products [7, 14]. *Gomphrena globosa* is an annual budding plant. Single flower that comes out from the end of the stem, rounded shape like a ball,

dark red-purple, white or pink in colour [15]. *Gomphrena globosa* commonly known as glove amaranth is an annual branched herb which is cultivated as ornamental flowering herb in garden [16].

It has been used for oliguria, heat and empacho, hypertension, cough and diabetes and expectorant for animals [17, 18]. The phytochemical components presented of flavonoids, saponins, alkaloids, reducing sugars and coumarins [19]. *Gomphrena globosa* flowers included the presence of epidermal cells, scalariform xylem vessels, medullary rays, lignified fibers, oil globules, crystals of calcium oxalate, tracheids and uniseriate multicellular trichome [20].

The major betacyanins identified in Globe Amaranth are gomphrenin, isogomphrenin II and isogomphrenin III [15]. *Gomphrena globosa* have been screened for pharmacological activities and reported to possess central and peripheral analgesic [21], anti-inflammatory [22], hypoglycemic [23], antihypertensive [19], anticancer [24], antimicrobial, antioxidant and cytotoxic activity [25].Dry flowers are economically important because fresh flowers are short lived and will retain only for few days or week while dry material will last indefinitely [26]. Drying flowers is an exotic physical process with the unique ability to preserve a life appearance and colour in beautiful blooms [27].

There were not many studies mentioned to drying of Gomphrena *globosa.* An investigation was carried out to standardize the medium and temperature for drying of *Gomphrena globosa* L. They were dried in silica gel and mixture of sand and silica gel for 3, 4 and 5 min. in microwave oven with 24, 48 and 72 h setting durations [28].

Therefore, objective of this our study focused on the effectiveness of processing variables such as the microwave power, system pressure and drying time on shrinkage coefficient, rehydration ratio, color change, total phenolic, flavonoid, betacyanin of dried herbal flower during the microwave vacuum (MV) drying of *Gomphrena globosa*

Materials and Method

Material

Gomphrena globosa flowers were collected from Soc Trang province, Vietnam. After collecting, they must be kept in cool and dry cotton box, conveyed to laboratory for experiments. They were subjected to the microwave vacuum drying under different conditions.

Researching Procedure

Effect of Microwave Power in drying to the Quality of Dried Gomphrena globosa Flower

Raw *Gomphrena globosa* flower were dried under various microwave power (100, 150, 200, 250, 300 W) by the same system pressure (20 kPa) and drying time (15 min). At the end of drying process, all samples were analyzed the shrinkage coefficient, rehydration ratio, color change, total phenolic (mg GAE/100 g), flavonoid (mg QE/100 g), betacyanin (mg/g) to validate the appropriate microwave power condition.

Effect of System Pressure in drying to the Quality of Dried Gomphrena globosa Flower

Raw *Gomphrena globosa* flower were dried under microwave power (250 W) by the different system pressure (20, 25, 30, 35, 40 kPa) and drying time (15 min). At the end of drying process, all samples were analyzed the shrinkage coefficient, rehydration ratio, color change, total phenolic (mg GAE/100 g), flavonoid (mg QE/100 g), betacyanin (mg/g) to validate the appropriate system pressure condition

Effect of drying Time in drying to the Quality of Dried Gomphrena Globosa Flower

Raw *Gomphrena globosa* flower were dried under microwave power (250 W) by the system pressure (35 kPa) and different drying time (15, 20, 25, 30, 35 min). At the end of drying process, all samples were analyzed the shrinkage coefficient, rehydration ratio, color change, total phenolic (mg GAE/100 g), flavonoid (mg QE/100 g), betacyanin (mg/g) to validate the appropriate drying time condition

Stability of Dried Gomphrena globosa Flower under Storage

After drying treatment, the dried *Gomphrena globosa* flower was subjected to storage. They were kept in PET/AL/PE (vaccum) bag at 28^{o}C.

The shrinkage coefficient, rehydration ratio, color change, total phenolic (mg GAE/100 g), flavonoid (mg QE/100 g), betacyanin (mg/g) will be evaluated in 12 months by 3 month-interval.

Physico-Chemical, Sensory and Statistical Analysis

The shrinkage coefficient was defined as the ratio of the volume (V) of a sample at any dryness level to that of the fresh sample (V_0). The shrinkage coefficient (S) was calculated as following equation: $S=V/V_0$

The rehydration ratio (RR) was defined as the ratio of the weight of the rehydrated sample (WR) to the weight of the dried sample (WD). The RR was calculated as the following equation: RR=WR/WD. Colour change was based on sensory score by a group of panelist using 9 point-Hedonic scales. Total polyphenol content (mg GAE/100 g) was determined by Folin Ciocalteu reagent method [29].Aluminum chloride colorimetric method was used for flavonoids (mg QE/100 g) determination [30, 31]. Spectrophotometric method was used for the quantification of betacyanins content (mg/g) [32]. The experiments were run in triplicate with three different lots of samples. Statistical analysis was performed by the Stat graphics Centurion XVI.

Result & Discussion

Effect of Microwave Power in drying to the Quality of Dried *Gomphrena globosa* Flower

Microwave power and vacuum levels are key factors (Wanxiu Xu et al., 2018). Raw *Gomphrena globosa* flower were dried under various microwave power (100, 150, 200, 250, 300 W). Our result showed that the optimal microwave power should be 250 W to maintain the best quality of dried *Gomphrena globosa* flower (see Table 1).

Table 1: Effect of microwave power (W) in drying to the quality of dried *Gomphrena globosa* flower

Microwave power (W)	100	150	200	250	300
Shrinkage coefficient	0.49±0.02^{c}	0.51±0.04^{bc}	0.66±0.07^{b}	0.87±0.04^{a}	0.75±0.03^{ab}
Rehydration ratio	1.77±0.08^{c}	2.06±0.05^{bc}	2.42±0.09^{b}	3.05±0.03^{a}	2.74±0.07^{ab}
Color change (sensory score)	4.28±0.03^{d}	5.19±0.02^{c}	6.26±0.04^{b}	7.11±0.00^{a}	6.89±0.02^{ab}
Total phenolic (mg GAE/100g)	33.19±0.03^{a}	32.85±0.00^{ab}	32.74±0.02^{ab}	32.68±0.04^{b}	29.11±0.03^{c}
Total flavonoid (mg QE/100g)	22.48±0.01^{a}	22.25±0.03^{ab}	22.13±0.01^{ab}	22.04±0.01^{b}	20.19±0.04^{c}
Betacyanin (mg/g)	48.13±0.04^{a}	47.92±0.02^{ab}	47.58±0.05^{ab}	47.40±0.02^{b}	46.09±0.02^{c}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

The microwave power was found to be more influential than the system pressure [33]. One study investigated the changes in the total polyphenolic content and antioxidant properties after subjecting Pink Rock Rose (*Cistus creticus*) leaves to three different drying procedures, including convection drying (CD) at 40, 50 and 60 °C; vacuum-microwave drying (VMD) at 240 W microwave power; and combined drying consisting of convective pre-drying at 50 °C followed by vacuum-microwave finish drying at 240 W microwave power (CPD-VMFD).Convection drying at 40 °C and vacuum-microwave drying yielded dried leaves with the highest bioactive potential in terms of the total polyphenol content and antioxidant activity. The lowest bioactive potential was found in a product dried at 60 °C, which can be attributed to the possible degradation or changes in polyphenol structures under high temperatures [34].

Effect of System Pressure in drying to the Quality of Dried *Gomphrena globosa* Flower

Pressure and power level must be correctly chosen to maximize the efficiency. The drying rate was significantly raised with increase of the pressure or the MW power level, but the final quality of dried banana slices was lower [35]. Raw *Gomphrena globosa* flower were dried under different system pressure (20, 25, 30, 35, 40 kPa). Our results were noted in Table 2.

The optimal primary system pressure was recorded 35kPa so we choose this value for further experiments.

Table 2: Effect of system pressure (kPa) in drying to the quality of dried *Gomphrena globosa* flower

System pressure (kPa)	20	25	30	35	40
Shrinkage coefficient	0.87±0.04^{b}	0.89±0.02^{ab}	0.90±0.00^{ab}	0.92±0.02^{a}	0.92±0.02^{a}
Rehydration ratio	3.05±0.03^{b}	3.19±0.04^{ab}	3.35±0.01^{ab}	3.43±0.00^{a}	3.45±0.03^{a}
Color change (sensory score)	7.11±0.00^{c}	7.38±0.04^{bc}	7.49±0.07^{b}	7.88±0.05^{a}	7.90±0.00^{a}
Total phenolic (mg GAE/100g)	32.68±0.04^{c}	33.17±0.02^{b}	33.75±0.05^{ab}	33.98±0.03^{a}	34.01±0.02^{a}
Total flavonoid (mg QE/100g)	22.04±0.01^{b}	22.19±0.03^{ab}	22.85±0.01^{ab}	23.07±0.01^{a}	23.10±0.04^{a}
Betacyanin (mg/g)	47.40±0.02^{c}	48.61±0.03^{bc}	49.15±0.02^{b}	51.27±0.04^{a}	51.30±0.00^{a}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

Reducing microwave power and system pressure resulted in higher uniformity in temperature distributions. The average temperatures deviated slightly from the targeted drying temperatures at high microwave power. The highest shrinkage coefficient (0.3705±0.0233) and rehydration ratio (3.82±0.091) values were obtained at 800 W and 12.4 kPa [33].

Effect of Drying Time in Drying to the Quality of Dried *Gomphrena globosa* Flower

The microwave generates a specific quantity of energy, conveniently shortening the drying time [36, 37]. Raw *Gomphrena globosa* flower were dried under different drying time (15, 20, 25, 30, 35 min). Our results were noted in Table 3. The optimal drying time was recorded 30 min so we choose this value for further experiments.

Table 3: Effect of drying time to the quality of dried *Gomphrena globosa* flower

Drying time (min)	15	20	25	30	35
Shrinkage coefficient	0.92±0.02^{a}	0.88±0.03^{ab}	0.83±0.06^{ab}	0.81±0.02^{b}	0.68±0.04^{c}
Rehydration ratio	3.43±0.00^{a}	3.29±0.03^{ab}	3.15±0.01^{b}	2.87±0.04^{c}	2.19±0.06^{d}
Color change (sensory score)	7.88±0.05^{c}	8.23±0.02^{b}	8.39±0.04^{ab}	8.75±0.01^{a}	7.99±0.00^{bc}
Total phenolic (mg GAE/100g)	33.98±0.03^{a}	33.69±0.05^{ab}	33.54±0.00^{ab}	33.48±0.02^{b}	31.05±0.02^{c}
Total flavonoid (mg QE/100g)	23.07±0.01^{a}	23.01±0.03^{ab}	22.94±0.01^{b}	22.89±0.01^{bc}	20.33±0.04^{c}
Betacyanin (mg/g)	51.27±0.04^{a}	50.19±0.03^{b}	48.62±0.00^{c}	47.53±0.04^{d}	43.19±0.02^{e}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

An investigation was carried out to standardize the medium and temperature for drying of *Gomphrena globosa* L. They were dried in silica gel and mixture of sand and silica gel for 3, 4 and 5 min. in microwave oven with 24, 48 and 72 h setting durations.

The maximum scores for quality parameters (out of a total of 20) based on colour, texture, brittleness and shape retention were obtained when flowers were embedded in silica gel and kept for 3 min. with 72 h setting time in cv. Magenta and for 3 min. and kept for 24 h. setting in cv. White [28]. One sutdy investigated the effect of process parameters such as the microwave power (450-800 W), system pressure (12.40-31.20 kPa) and drying time (0-25 min) on the drying kinetics, quality characteristics and heating uniformity indices during the microwave vacuum (MV) drying of artichokes [33].

Stability of Dried *Gomphrena globosa* Flower during Preservation

At the end of the drying treatment, the dried *Gomphrena globosa* flower was subjected to

storage. They were kept in PET/AL/PE (vaccum) bag at 28°C. The shrinkage coefficient, rehydration ratio, color change, total phenolic (mg GAE/100 g), flavonoid (mg QE/100 g), betacyanin (mg/g) will be evaluated in 12 months by 3 month-interval (see Table 4).

Table 4: Stability of dried *Gomphrena globosa* flower during preservation

Storage time (months)	0	3	6	9	12
Shrinkage coefficient	0.81 ± 0.02^{b}	0.81 ± 0.02^{b}	0.83 ± 0.01^{ab}	0.85 ± 0.00^{ab}	0.89 ± 0.03^{a}
Rehydration ratio	2.87 ± 0.04^{c}	2.85 ± 0.01^{ab}	2.84 ± 0.00^{b}	2.80 ± 0.01^{bc}	2.77 ± 0.02^{c}
Color change (sensory score)	8.75 ± 0.01^{a}	8.74 ± 0.00^{a}	8.70 ± 0.04^{ab}	8.67 ± 0.02^{ab}	8.63 ± 0.01^{b}
Total phenolic (mg GAE/100g)	33.48 ± 0.02^{a}	33.37 ± 0.05^{ab}	33.32 ± 0.04^{b}	33.29 ± 0.00^{bc}	33.18 ± 0.04^{c}
Total flavonoid (mg QE/100g)	22.89 ± 0.01^{a}	22.81 ± 0.04^{ab}	22.73 ± 0.01^{ab}	22.64 ± 0.02^{ab}	22.59 ± 0.01^{b}
Betacyanin (mg/g)	47.53 ± 0.04^{a}	47.03 ± 0.05^{ab}	46.88 ± 0.04^{ab}	46.57 ± 0.00^{ab}	46.48 ± 0.04^{b}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

Conclusion

The benefit of drying is not only to preserve crops as food but also reduce package and transport cost in terms of weight and volume, while offering the possibility of adding value to harvested commodities. Microwave vacuum drying is more energy-efficient than microwave convective drying. *Gomphrena globosa* L. (Amaranthaceae) is used in folk medicine in the treatment of high blood pressure and other diseases.

We have successfully studied major technical variables affecting to the drying process of *Gomphrena globosa* floral. Microwave energy can dramatically enhance drying of medicinal and aromatic plants, save energy and preserve product quality if properly applied in combination with hot vacuum drying. From this study, the added value of *Gomphrena globosa* floral would be improved and consumer would have more chance to enjoy a benifical healthy dried tea.

References

1. Valérie Orsat, Viboon Changrue, GS Vijaya Raghavan (2006) Microwave drying of fruits and vegetables. Stewart Postharvest Review, 6(4): 1-7.
2. Albert GW Heindl, Joachim Müller (2007) Microwave drying of medicinal and aromatic plants. Stewart Postharvest Review, 4(5): 1-6.
3. MN Berteli, E Rodier, A Marsaioli Jr (2009) Study of the microwave vacuum drying process for a granulated product. Brazilian Journal of Chemical Engineering, 26(2): 317-329.
4. Péré C, Rodier E (2002) Microwave vacuum drying of porous media: experimental study and qualitative considerations of internal transfers. Chemical Engineering and Processing 2002; 41: 427-441.
5. PS Sunjka, TJ Rennie, C Beaudry, G SV Raghavan (2004) Microwave-convective and microwave-vacuum drying of cranberries: A comparative study. Drying Technology, 22(5): 1217-1231.
6. SK Giri, PP Sutar, Suresh Prasad (2014) Effect of process variables on energy efficiency in microwave-vacuum drying of button mushroom. Journal of Food Research and Technology, 2(1): 31-38.
7. A Figiel (2009) Drying kinetics and quality of vacuum-microwave dehydrated garlic cloves and slices. Journal of Food Engineering, 94(1): 98–104.
8. Á Calín-Sánchez, A Figiel, A Wojdyło, M Szarycz, ÁA Carbonell-Barrachina (2014) Drying of garlic slices using convective pre-drying and vacuum-microwave finishing drying: kinetics, energy consumption, and quality studies. Food and Bioprocess Technology, 7(2): 398-408.
9. S Ferenczi, B Czukor, Z Cserhalmi (2014) Evaluation of microwave vacuum drying combined with hot-air drying and compared with freeze- and hot-air drying by the quality of the dried apple product. Periodica Polytechnica Chemical Engineering, 58(2): 111-116.
10. S Ambros, SAW Bauer, L Shylkina, P Foerst, U Kulozik (2016) Microwave-vacuum drying of lactic acid bacteria: influence of process parameters on survival and acidification activity. Food

and Bioprocess Technology, 9(11): 1901-1911.

11. J de Bruijn, F Rivas, Y Rodriguez (2016) Effect of vacuum microwave drying on the quality and storage stability of strawberries. Journal of Food Processing and Preservation, 40(5): 1104-1115.
12. M Zielinska, P Sadowski, W Błaszczak (2016) Combined hot air convective drying and microwave-vacuum drying of blueberries (Vaccinium corymbosum L.): Drying kinetics and quality characteristics. Drying Technology, 34(6): 665-684.
13. Y Tian, S Wu, Y Zhao, Q Zhang, J Huang, B Zheng (2015) Drying characteristics and processing parameters for microwave-vacuum drying of kiwifruit (Actinidia deliciosa) slices. Journal of Food Processing and Preservation, 39(6): 2620-2629.
14. D Wray, HS Ramaswamy (2015) Quality attributes of microwave vacuum finish-dried fresh and microwave-osmotic pretreated cranberries. Journal of Food Processing and Preservation, 39(6): 3067-3079.
15. Edla Chandana, CH Pradeep Kumar (2018) A review on different pharmacological activities of Gomphrena globosa L. World Journal of Pharmacy and Pharmaceutical Sciences, 7(8): 386-394.
16. Muller K, Borsch T (2005) Phylogenetics of Amaranthaceae using matK/trnK sequence data-evidence from parsimony, likelihood and Bayesian approaches. An Missouri Bot. Garden, 92: 66-102.
17. Yusuf AA, Iwuafor ENO, Abaidoo RC, Olufajo OO, Sanginga N (2009) Grain legume rotation benefits to maize in the northern Guinea savanna of Nigeria: Fixed-nitrogen vs. other rotation effects. Nutr. Cycl. Agroecosyst, 84: 129-139.
18. Arcanjo DDR, De Albuquerque, ACM Neto BN, Silva NCBS Moita MM (2011) Phytochemical screening and evaluation of cytotoxic, antimicrobial and cardiovascular effects of Gomphrena globosa L ethanolic extraction. J. Med. Plants Res., 5: 2006-2010.
19. Daniel Dias Rufino Arcanjo, Ingrid Virgínia de Oliveira Sena, Adonai Carvalho Medeiros de Albuquerque, Bernardo Melo Neto, Lorena Citó Lopes Resende Santana, Náiguel Castelo Branco Silva, Maria Marilza Moita, Maria das Graças Freire de Medeiros, Maria José dos Santos Soares, Nilza Campos de Andrade, Antônia Maria das Graças Lopes Citó (2011) Phytochemical screening and evaluation of cytotoxic, antimicrobial and cardiovascular effects of Gomphrena globosa L. (Amaranthaceae). Journal of Medicinal Plants Research, 5(10): 2006-2010.
20. Syeda Nishat Fathima, S Vasudeva Murthy (2018) Investigation of pharmacognostical and physical parameters of Gomphrena globosa flowers. Journal of Innovation in Pharmaceutical Sciences, 2(2): 7-12.
21. Hamiduzzaman M (2013) Significant hypoglycemic activity from Gomphrena globosa (Amaranthaceae) in mice model. Universal Journal of Pharmacy, 02 (05): 68-72.
22. Luis RS, Patrícia V, Joana F, Federico F, Carla S, Angel G, Brígida RP, Paula BA (2012) Phytochemical investigations and biological potential screening with cellular and non cellular models of globe amaranth (Gomphrena globosa L.) inflorescences. Food Chemistry, 135(2): 756-763.
23. Hamiduzzaman M (2013) Evaluation of central and peripheral analgesic activity of whole plant Gomphrena globosa (L), family: Amaranthaceae. International Research Journal of Pharmacy, 4(6): 54-57.
24. Latha ST, Rajendran NN, Babu G (2013) Anticancer screening of Gomphrena globosa against ehrlich ascites carcinoma in swiss albino mice. Journal of Chemical and Pharmaceutical Research, 5(2):283-289.
25. Md Hamiduzzaman, ATM Zafrul Azam (2012) Antimicrobial, antioxidant and cytotoxic activities of Gomphrena globosa (L.). Bangladesh Pharmaceutical Journal, 15(2): 183-185.
26. Shailza, Shalini Jhanji, HS Grewal (2018) Emerging prospective of floriculture industry: drying of ornamental plants and their parts. International Journal of Current Microbiology and Applied Sciences, 7(7): 1619-1633.
27. A Sankari, M Anand (2014) Process of making-waste into wealth-dry flower technology. The Asian Journal of Horticulture, 9(2): 466-483.

28. Sangeeta Kumari, Bharati Kashyap, Youdh Chand Gupta (2017) Studies on microwave oven drying of Gomphrena globosa L. Indian Journal of Horticulture 74(1): 146-151.

29. Hossain MA, Raqmi KAS, Mijizy ZH, Weli AM, Riyami Q (2013) Study of total phenol, flavonoids contents and phytochemical sreening of various leaves crude extracts of locally grown Thymus vularis. Asian Pacific Journal of Tropical Biomedicine, 3(9): 705-710.

30. Eswari ML, Bharathi RV, Jayshree N (2013) Preliminary phytochemical screening and heavy metal analysis of leaf extracts of Ziziphus oenoplia (L) Mill. Gard. International Journal of Pharmaceutical Sciences and Drug Research, 5(1): 38-40.

31. Mandal S, Patra A, Samanta A, Roy S, Mandal A, Mahapatra TD, Pradhan S, Das K, Nandi DK (2013) Analysis of phytochemical profile of Terminalia arjuna bark extract with anti-oxidative and antimicrobial properties. Asian Pacific Journal of Tropical Biomedicine, 3(12): 960-966.

32. Custódio Lobo Roriz, Lillian Barros, MA Prieto, Patricia Morales, Isabel CFR Ferreira (2017) Floral parts of Gomphrena globosa L. as a novel alternative source of betacyanins: Optimization of the extraction using response surface methodology. Food Chemistry, 229: 223-234.

33. Ç Muştu, İ Eren (2019) Drying kinetics, is heating uniformity and quality changes during the microwave vacuum drying of artichokes (Cynara Scolymus L.). Ital. J. Food Sci., 31: 681-702.

34. Agnieszka Ewa Stępień, Józef Gorzelany, Natalia Matłok, Krzysztof Lech, Adam Figiel (2019) The effect of drying methods on the energy consumption, bioactive potential and colour of dried leaves of Pink Rock Rose (Cistus creticus). Journal of Food Science and Technology, 56(5): 2386-2394.

35. Drouzas AE, Tsami E, Saravacos GD (1999) Microwave/vacuum drying of model fruit gels. Journal of Food Engineering, 39: 117-122.

36. Wenjiang Dong, Ke Cheng, Rongsuo Hu, Zhong Chu, Jianping Zhao, Yuzhou Long (2018) Effect of microwave vacuum drying on the drying characteristics, color, microstructure, and antioxidant activity of green coffee beans. Molecules, 23(1146): 1-16.

37. Wanxiu Xu, Guanyu Zhu, Chunfang Song, Shaogang Hu, Zhenfeng Li (2018) Optimization of microwave vacuum drying and pretreatment methods for Polygonum cuspidatum. Mathematical Problems in Engineering, article ID 4967356, 11.

