An Evaluation Of Physio-Chemical And Functional Properties Of Vegetables Through Different Drying Methods

Anukriti[1], Singh Neetu[2]

[1] Research Scholar, Department Of Human Development and Family Studies, Babasaheb Bhimrao Ambedkar University A Central University, Lucknow, India

[2] Associate Professor, Department Of Human Development and Family Studies, Babasaheb Bhimrao Ambedkar University A Central University, Lucknow, India

Email: [1]anukritibbau03@gmail.com, [2]neetubbau@gmail.com

Abstract

The impact of solar and sun drying on physical properties of vegetable samples was determined. Ash content of sun and solar dried samples were significantly (p<0.05) increased compared to fresh samples. Ash content of spinach, Fenugreek, Cauliflower, Tomato, Chenopodium treated under sundry were (16.05± 0.03), (3.23± 0.14),(6.57± 0.28),(1.01± 0.01),(4.31± 0.16) respectively while ash content of spinach, Fenugreek, Cauliflower, Tomato, Chenopodium treated under solar dry were (17.63± 0.31), (3.33± 0.17), (7.80± 0.11), (2.01± 0.05), (5.33± 0.14) respectively. Angle of repose of spinach, Fenugreek, Cauliflower, Tomato, Chenopodium treated under sundry were (40.71±0.31), (30.70±0.30), (99.76±0.39), (65.43±0.43), (49.46±0.51) orderly while Angle of repose of spinach, Fenugreek, Cauliflower, Tomato, Chenopodium treated under solar dry were (41.28±0.30), (44.26±0.36), (105.10), (67.19±0.93), (57.62±1.47) respectively. True density of spinach, Fenugreek, Cauliflower, Tomato, Chenopodium treated under sundry were (783.00±3.00), (749.66±4.63), (285.00±2.30), (347.46±3.05), (147.73±4.77) sequentially while True density of spinach, Fenugreek, Cauliflower, Tomato, Chenopodium treated under solar dry were (901.95±2.53), (850.29±0.35), (296.66±0.88), (358.06±3.47), (147.73±0.81) successively. All methods of drying found to significantly (p<0.05) lower moisture, Ash, angle of repose, bulk density , true density, hydration and water absorption capacity in compare to their fresh samples. In respect to density the bulk density and true density was quit low in sundried vegetable samples relative to solar dried vegetable samples. Swelling index, swelling capacity, hydration level, water solubility were seen reduced in sun dried vegetable samples rather than solar dried. Solar drying may be preferred method of drying the vegetable samples, as it is faster more hygienic preserve the nutrients better.

Key words: Sun dry, Solar dry, Swelling index, Angle of repose, Chenopodium

Introduction

Green vegetables (GVs) are a privilege and have been in use for decades for a secure and healthy lifestyle. To satisfy the regular nutritional needs, these are regarded as an integral component of the nutrition. GVs are a nutrient-rich product, strong in dietary fibre poor in fats, and abundant in folate, vitamins K, ascorbic acid, Mg, and K. They also bring a number of bioactive compounds, like flavonoids. In reducing the incidence of heart disorders & cancer, GV's healthy nutritional quality is helpful. Because of their higher Mg value high in fibre quality, and lower glycaemic index, GVs are also appreciated for people with type 2 diabetes (Randhawa et al., 2015).

The intake of vegetables within deprived rural populations has been observed to be seasonal. Low usage is partially due to the assumption that vegetables farming is mainly small-scale and rain-fed. Restricted processing and harvesting of wild vegetables has been developed in rural areas, resulted in a severe shortage of relish, particularly in the dry season, and thus leading to household food insecurity. Owing to ineffective and inefficient storage methods, the relish shortage is further exacerbated by high postharvest losses (Kiremire et al., 2010). In order to improve the intake of leafy vegetables, they need to be stored once they are abundant mostly during wet season, so that these can be utilized once they are limited in lean seasons. In this way, by broadening the food base, they can add to household food security and nutritional quality. Significant importance is being given to the consistency of foods throughout the drying process in recent times. All across the globe, a requirement for high-quality processed food items has increased Improving the shelf life of products is the primary objective of drying; decreasing packaging demands and decreasing bulk weight. the drying system enhances the shelf life By slowing down the microbial growth and avoiding certain biochemical changes that may alter the organoleptic features (Rahimmalek & Goli, 2013). In addition, there is increasing concern in discovering biologically existing antioxidant in vegetables or therapeutic substances for ingestion to substitute synthetic antioxidants, that are limited because of its carcinogenic effects (Generalić et al., 2012).

Along with their cheaper price, natural drying (drying in the shade or in the sun) and warm air drying are the most commonly utilized processes. Owing to the failure to manage vast amounts and to attain acceptable quality levels, natural drying has several drawbacks. One of its most commonly utilized procedures for food dehydration is traditional air drying. High apparent density & Low porosity are seen in total goods. During air drying, major colour changes take place and the end material has poor sorption power (Hamrouni-Sellami et al., 2013). Furthermore, hot air processing has some advantages, like lower power efficiency and long drying period in the last drying phase. In addition, microwave drying methods will significantly minimize the drying time of organic matter without yield loss as opposed to hot air drying. Microwave heating has recently gained prominence for a range of food products such as fruits, vegetables, snack foods and dairy products as an alternative drying process(Sellami et al., 2012). Freeze processing is among the more advanced techniques of dry that offers dry goods with such a highly porous associated with minimal or insignificant shrinkage, superior preservation of flavour and aroma, and better rehydration behaviour compared to alternative drying process products. As a consequence, the final product consistency can be managed by selecting an appropriate drying system and suitable environments (Hamrouni-Sellami et al., 2013).

Much of the preceding research on vegetable was performed on restricted methods of drying (Hirun et al., 2014). In addition, drying procedures can improve the functional and quantitative properties of vegetables, such as vitamins, colour, chlorophyll, total flavonoids, total phenolic content and final product antioxidant activity, but one or two qualitative aspects have been studied in most previous studies. In addition, no detailed studies were accessible to the maximum of our expertise on variability in ash content, yield, moisture content, bulk density, angle of repose, mineral content, capacity to absorb water, index of swelling power and solubility of vegetables under sundry and solar drying methods (Roshanak et al., 2016)

Methodology:

<u>Chemicals:</u>

Analytical grade chemicals were used in entire experiments.

<u>Sample collection:</u>

Total five samples were collected namely, Spinach (*Spinacia oleracea***)**, Fenugreek (*Trigonella foenum graecum***)**, Cauliflower (Brassica *oleracea***)**, tomato (*Solanum lycopersicum*), chenopodium (*Chenopodium album*) from vegetable market, Gomati Nagar Lucknow, India. The research was done at Department of Biochemistry, MRD Life Sciences Pvt. Ltd., Gomati Nagar Lucknow, India.

<u>Plant preparation:</u>

Collected sample were washed with distilled water to remove the dust and some Portion was dried to constant weight employing two drying methods. Fresh samples were used as control.

<u>Sun Drying:</u>

The leaves were kept under the sun (ambient temperature 35-41°C) in July 2020, between 10 am- 5 pm daily till leaves attained constant weight.

Solar Drying:

A solar dryer SD 800 was employed as dryer for samples. The dryer is combine direct and indirect rocked thermal storage passive cabinet dryer. The dryer stores heat in rock bed, a device intended to overcome temperature fluctuation during sun set hours. The temperature of drying chamber ranged between 42 and 63°C while that of the solar dryer of the leaves collector was between 40 and 73°C. Solar drying of the samples took place between 10.am - 5.pm daily till the sample attained a constant weight (Matazu & Haroun, 2004).

Yield:

Fresh sample was weighted and then it was dried under sun and solar dryer. Weight of dried sample was taken; Yield (percentage) was estimated by employing following formula:

$$\text{Yield (\%)} = \frac{\text{Dry sample weight} \times 100}{\text{Wet sample weight}}$$

Moisture:

Moisture of blank plates first was dried for 1 h in a pre-heated oven (100 ± 1 ° C). Plate was then cooled in a desiccator for 30 min. In the pre-weighed plates, approximately 5 g of samples were precisely weighed and put in the Solar dryer and under the sun light. These samples were dried. The drying, weighing processes were repeated until constant weight was acquired (Baradey et al., 6 C.E.). The outcomes were determined in percentage using the following equation:

$$\text{Moisture Content (\%)} = \frac{\text{W1-W2}}{\text{Weight of Samples}} \times 100$$

Where,
W1= weight of sample before drying.
W2 = weight of sample after drying.

Ash (%)

After drying in solar dryer and under the sun, complete ash content was measured by burning the materials at 500 °C for 6 hours in a pre-weighed crucible in a muffle furnace (Rao & Xiang, 2009). The residue ash weight was recorded after burning and the ash weight was measured employing the formula:

$$\text{Total Ash (\%)} = \frac{\text{Weight of Ash}}{\text{Weight of Samples}} \times 100$$

Determination of bulk density:

A 20g amount of the sample was put in a 10ml measuring cylinder, & the volume covered by the specimen was recorded as the volume of the bulk. By dividing the mass of the material by the bulk volume, the bulk density was obtained as shown in Equation (Arivuchudar, 2018):

Bulk Density = Mass of the materials (M)/ Volume of the materials (VB)

Angle of repose:

The angle of repose of the sample was calculated by using a 50 x 100mm x 150 mm sized movable inclined metal plane box, respectively in depth width and length. For measuring system in the analysis of the angle of repose at various intervals, the samples were filled up in the box and levelled by a scale throughout the time. This helps the box to carry the full volume of samples.

Water absorption capacity (WAC):

Water absorption was measured using a modification of the centrifugation technique of (Sultan et al., 2020). Two grams of Moringa Oleifera flour was weighed into a 50-ml centrifuge tube and mixed with 25 ml of distilled water with continuous stirring for 1 minute. The resulting slurry was centrifuged at 3075 × g for 30 minutes. The supernatant was then decanted, and the water retained per gram sample was calculated.

Swelling power and solubility:

A weighed amount of sample with known moisture content was mixed with a measured volume of distilled water and heated at varying temperatures of 55, 65, 75, 85 and 95°C respectively in a temperature controlled water bath for 30 min with intermittent stirring. After heating, the slurry was centrifuged (3000 g; 20 min) and supernatant was drawn off and evaporated to dryness on steam bath to obtain a measure of the dissolved solids. The sediment flour obtained after centrifugation was weighed to get the weight of the swollen flour particles. The values were expressed as percentages of total dissolved solids (solubility) and total swollen flour particles (swelling power) with respect to the weight of the flour sample used (Schoch, 1964).

Statistical Analysis:

Values are presented as mean standard deviation. Analysis of variance, complete randomized design statistical analytical system (1988), SAS/STAT user's guide release (6, 035. A. Cary, N.C., USA) was used to analyse the data. A least significant difference (LSD) at 5% probability was considered significant.

Results:

1. Effect of drying system on yielding of product:

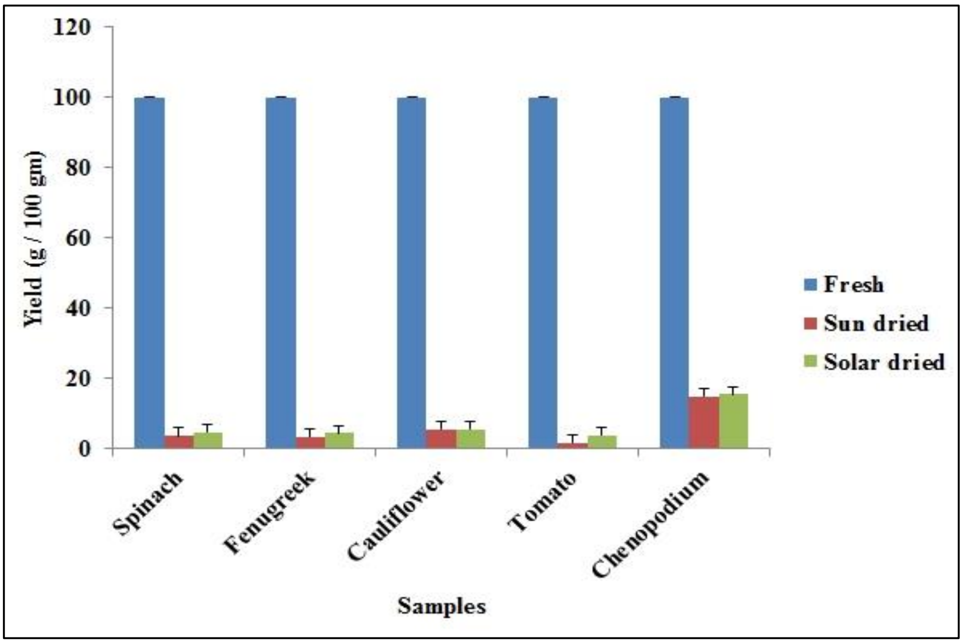

Figure 1: Impact of drying system on product yielding. Data inferred that among all vegetables maximum product yielding was seen in solar dry rather than sundry. Maximum product yielding was achieved in chenopodium, Fenugreek, Cauliflower, Spinach, tomato showed less product yielding.

2. Influence of drying system on Ash:

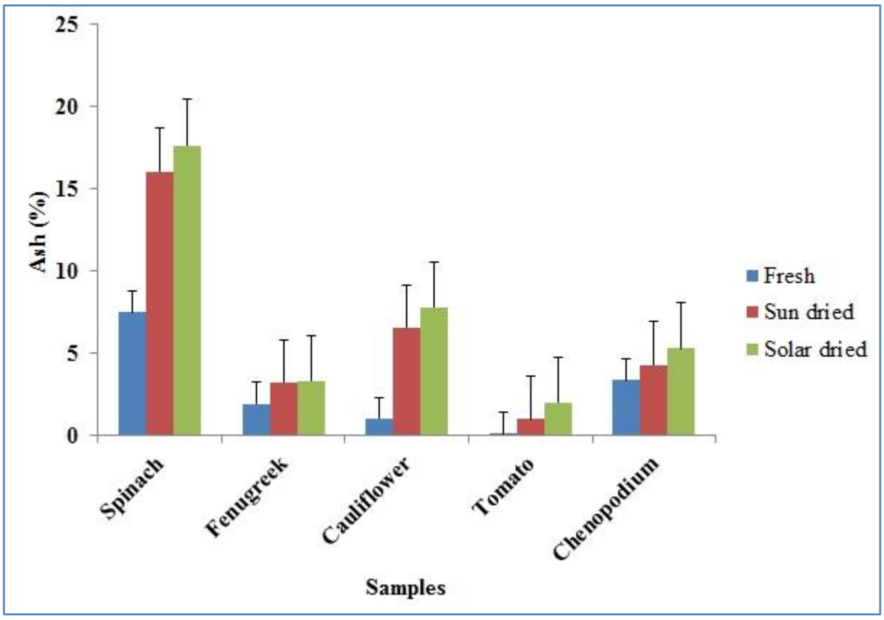

Figure 2: Influence of drying system on Ash content. Maximum percentage of ash was achieved from sample treated with solar dry in relative to sundry. Among the all samples sp

3. **Impact of drying techniques on bulk density of vegetable samples:**

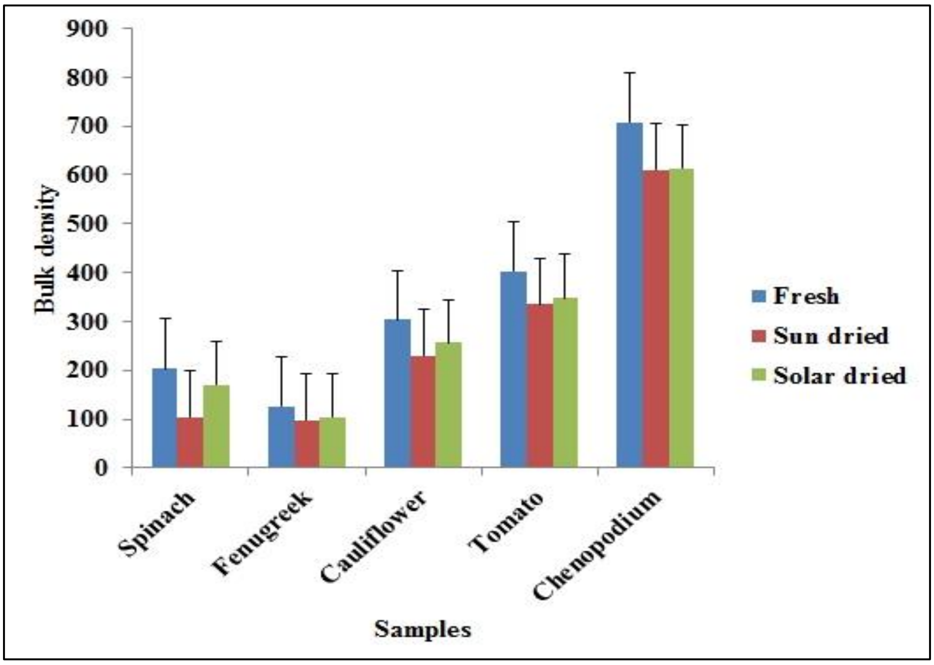

Figure 3: Effect of drying systems on bulk density. Outcomes depicted that both solar dry and sundry systems have lowered the bulk density in all treated samples. In comparative to solar dry, sundry has highly reduced the bulk density. In spinach, fenugreek and cauliflower the reduction level of bulk density was less while high reduction in bulk density was seen in Chenopodium and tomato.

4. Change in true density of product on drying:

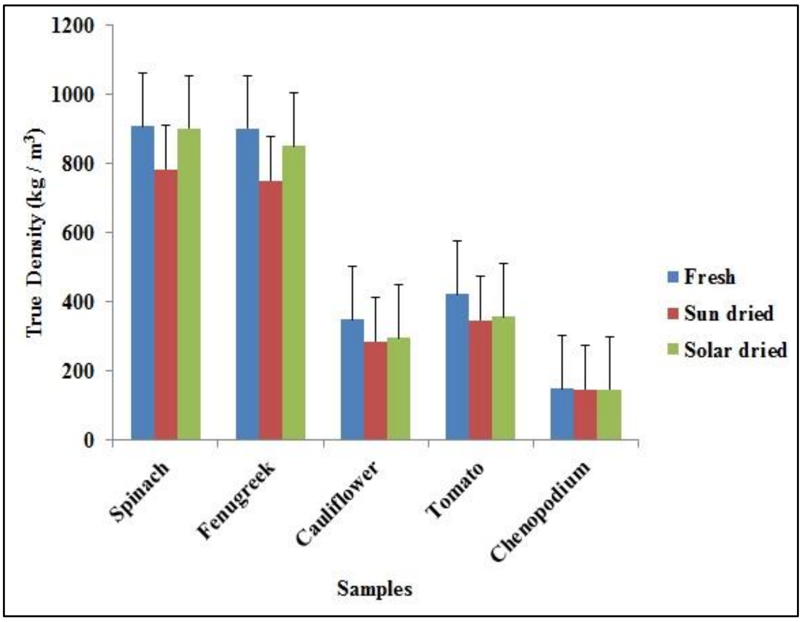

Figure 4: Influence of drying process on true density. Results inferred that on drying under sundry and solar dry, true density was brought down in all treated samples. In comparison to solar dry, sundry has highly reduced the true density. In chenopodium, true density reduction level was seen very low. In spinach and fenugreek, high reduction of true density was observed and in cauliflower and tomato, moderate reduction of true density was seen.

5. Variability in angle of repose on drying:

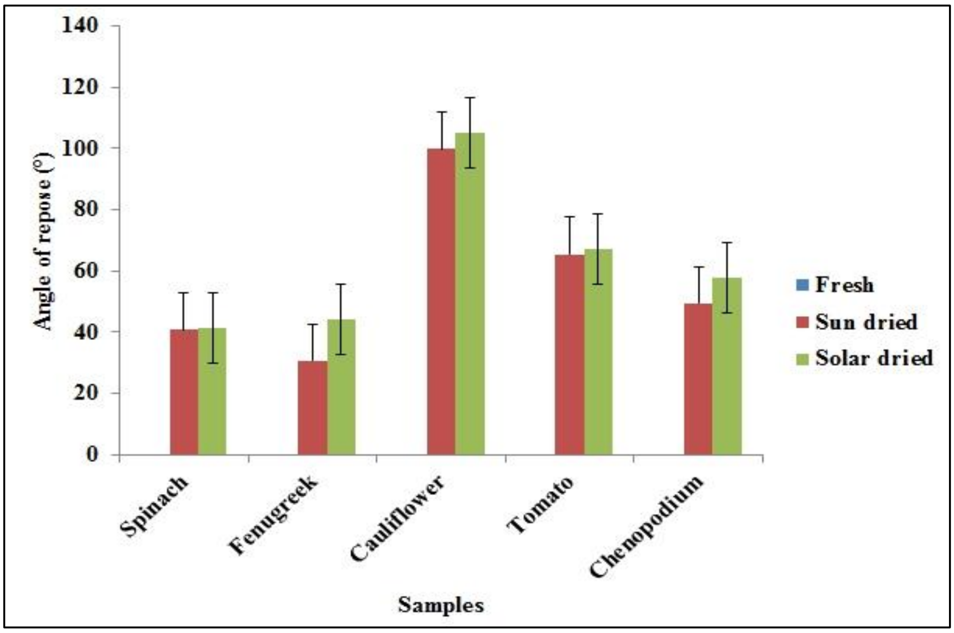

Figure 5: Comparative analysis of effect of drying system on angle of repose of treated samples. It was observed that samples dried under the sun have lower angle of repose in comparison to solar dry. Cauliflower has high angle of repose among the all-vegetable samples.

6. Variation in water absorption capacity of samples on drying:

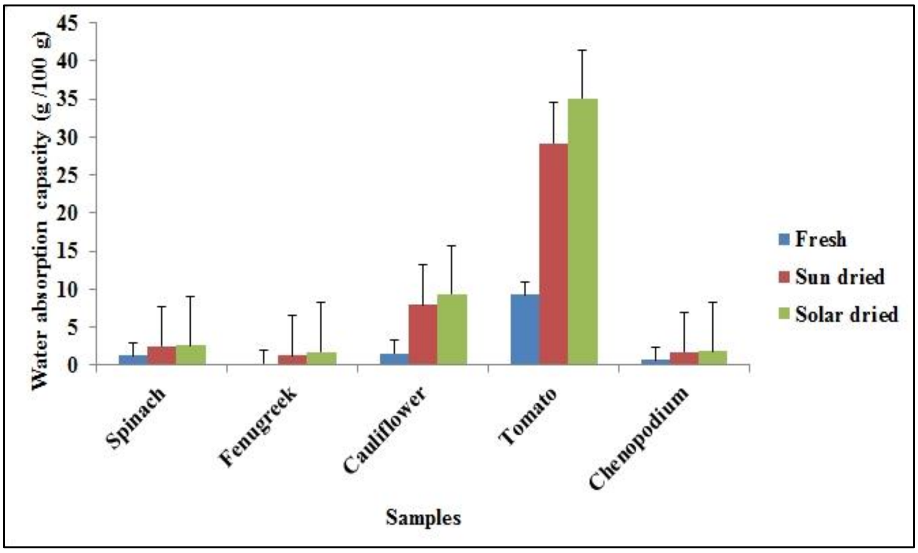

Figure 6: Outcomes of influence of drying systems on water absorption capacity. Obtained data inferred that samples those are dried in solar dryer have high water absorption capacity while samples dried under sun have low water absorption capacity. Tomato has high water absorption capacity among the all samples.

7. Change in hydration capacity on drying:

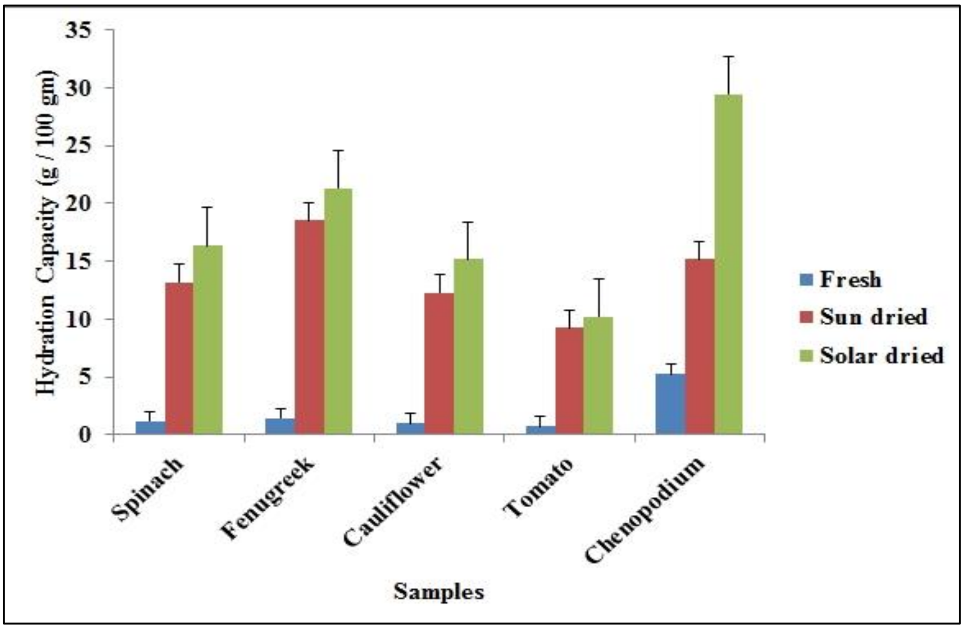

Figure 7: Influence of drying process on hydration capacity. Results obtained from experiments depicted that samples dried under the sun have lower hydration capacity while samples dried under the solar dryer have high hydration capacity. Chenopodium has high hydration capacity while tomato has lowest hydration capacity among the all treated samples.

8. Variation in swelling capacity of dried samples:

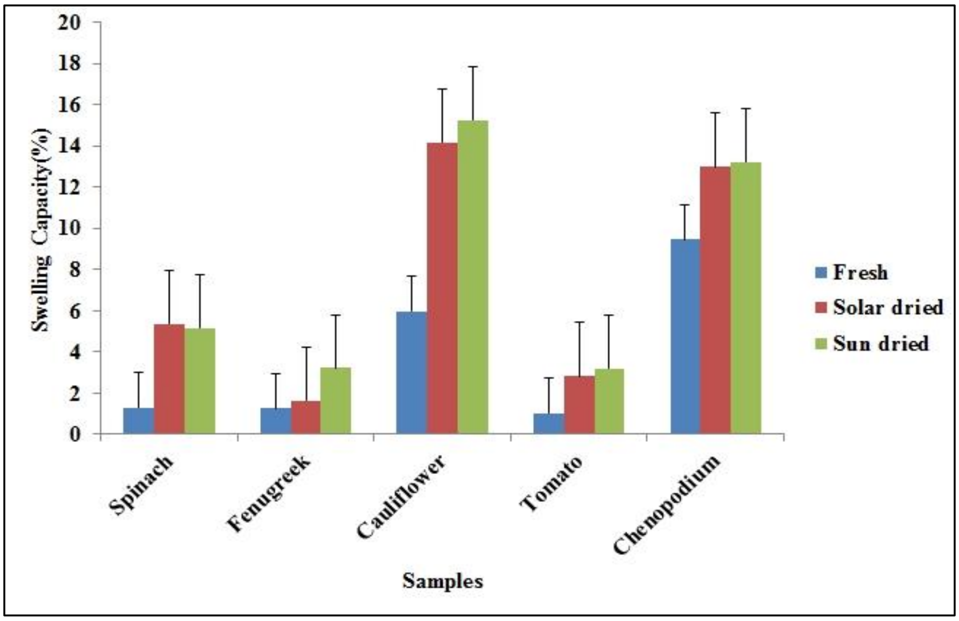

Figure 8: Effects of drying process on swelling capacity of treated samples. Results depicted that sundried treated samples have low swelling capacity while solar dried samples have high swelling capacity. Among the all samples, Cauliflower has highest swelling capacity while tomato has lowest swelling capacity.

9. Change in swelling index of vegetable samples:

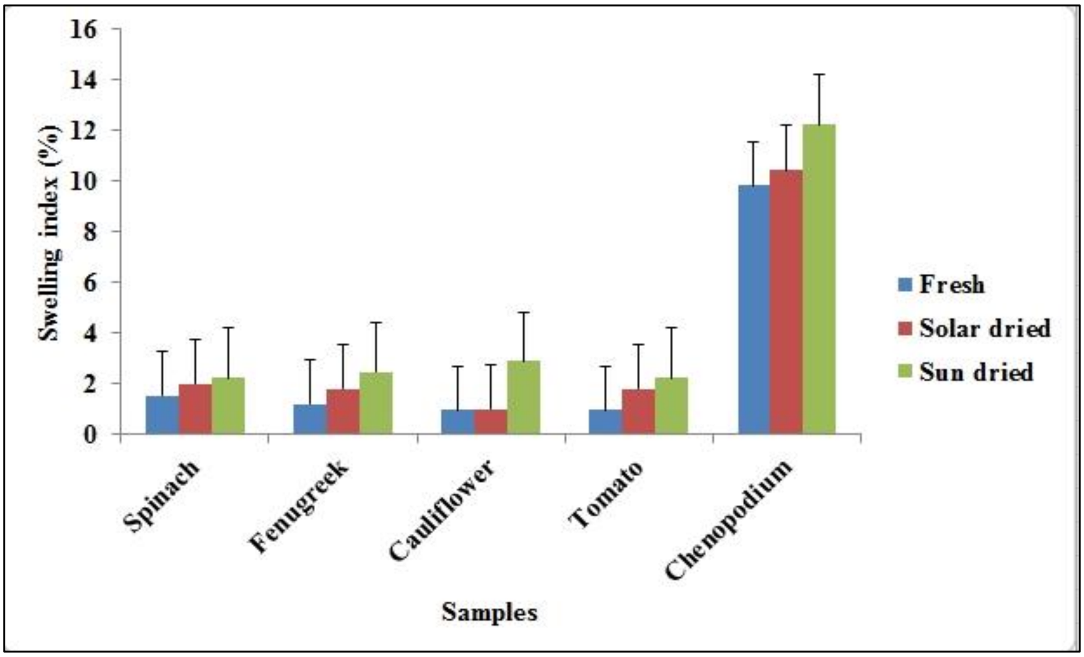

Figure 9: Impact of drying procedures on swelling index of treated vegetable samples. Outcomes elaborated that samples dried under the solar dryer have high swelling index while samples dried under sundry have low swelling index. Maximum swelling index was seen in chenopodium, tomato and cauliflower had less swelling index.

Discussion:

Elimination of moisture through heat commonly enhances the foods digestion, rise in quantity of nutrients and may make few nutrients more available (Morris & Tangney, 2014)**.**

Moisture level of vegetables impart an enabling environ for progression of microorganisms, thus this has to be brought down if vegetables are to be safeguard for long time to be employed and it can impede autolytic action of enzyme (Landan et al., 1997). Our experimental results inferred moisture level is highly reduced in sundry rather than solar dry. Angle of repose also depends on moisture level (Bhople et al., 2017). It is clear from experiments that angle of repose is high in solar dry sample due to high moisture content in comparison to sundry sample. Results tallied with assertion of Shraddha et al. (2017) that there is linear relationship of moisture and angle of repose.

Swelling index denotes the degree of granule hydration (Lopez**-** Reyes et al., 2010). The swelling capacity of vegetables powder reflects the increase in its volume following water absorption. Although, the Vegetable powders exhibited high swelling index on solar drying. The results of the analysis of variance (ANOVA) at 0.05 level of significance, reveal significant differences in the % swelling index among the vegetables. Swelling capability of excipient is related to wetting properties. High swelling capability may be due to excellent wetting property, which is the ability to form more viscous mixtures (Kumar et al., 2013). Swelling could be a result of entanglement of the polysaccharide chains and development of intra-and inter-molecular hydrogen bonds between the polysaccharide and water causing more water to be entrapped within the macromolecular chains (Kumar et al., 2013). The increase entrance of water may result in the disruption of H-bonds holding the molecules together thereby breaking up the tablet (Kumar et al., 2013). Water absorption capacity (WAC) and hydration values were determined as an indicator of degradation of molecular components. It was found that WAC and hydration level decreased as the particle size decreases. For coarse particles moisture diffusion occurred at a higher rate. Thus, the structure of powder reflects more porous, which has resulted in increased weight of sediment reflected more WAC (Prasad & Prasad, 2013), samples treated with sun dry had less water absorption and hydration capacity in comparative to solar dry. During the drying process, the volume of the food may change due to the shrinkage and or collapse phenomena. It is possible that all the volume of the removed water is replaced by air and the initial air, represented by initial porosity, does not disappear. In this case, neither shrinkage nor collapse occurs and the volume of the food keeps constant. However, whenever shrinkage and or collapse phenomenon occurs, the food volume will decrease. The shrinkage and or collapse phenomena of food matrixes, experienced during drying, have direct impact on volume reduction, bulk density, and porosity of food products. These modifications of the material structures can significantly influence the process performance; e.g., drying rate and mass and heat transfers (Madiouli et al., 2012). They are also of importance to food quality and therefore have significant impact on the consumer's choice (Madiouli et al., 2012).

Conclusion:

Physical properties of vegetable powder are temperature dependent, particle size dependent and treatment has effect on it. Powder of vegetables treated under solar dry was found more compact structure with more moisture content, less angle of repose, high true density, bulk density, hydration level as compared to the sun dry leaf powder. The solar dry can be better method of drying for storage of vegetables relative to sun drying method that protect quality of green leafy vegetable powder of wider acceptability.

References

1. Arivuchudar, R. (2018). Assessment of Functional Properties of Flour Mix. *International Journal of Food and Fermentation Technology*, *8*(1), 81–85.
2. Baradey, Y., HAWLADER, M., ISMAIL, A., & Hrairi, M. (6 C.E.). Drying of Fruits and Vegetables. *Advances in Heat Pump-Assisted Drying Technology*, *1*, 189–199.
3. Bhople, S., Singh, M., & Thakur, S. (2017). Effect of process and machine parameters on physical properties of extrudate during extrusion cooking of rice, ashwagandha powder and spinach powder blends. *International Journal of Computer Systems (IJCS), 5*(6), 1657–1662.

4. Generalić, I., Skroza, D., Šurjak, J., Možina, S. S., Ljubenkov, I., Katalinić, A., Šimat, V., & Katalinić, V. (2012). Seasonal variations of phenolic compounds and biological properties in sage (Salvia officinalis L.). *Chemistry & Biodiversity*, *9*(2), 441–457.
5. Hamrouni-Sellami, I., Rahali, F. Z., Rebey, I. B., Bourgou, S., Limam, F., & Marzouk, B. (2013). Total phenolics, flavonoids, and antioxidant activity of sage (Salvia officinalis L.) plants as affected by different drying methods. *Food and Bioprocess Technology*, *6*(3), 806–817.
6. Hirun, S., Utama-Ang, N., & Roach, P. D. (2014). Turmeric (Curcuma longa L.) drying: an optimization approach using microwave-vacuum drying. *Journal of Food Science and Technology*, *51*(9), 2127–2133.
7. Kiremire, B. T., Musinguzi, E., Kikafunda, J. K., & Lukwago, F. B. (2010). Effects of vegetable drying techniques on nutrient content: a case study of south-western Uganda. *African Journal of Food, Agriculture, Nutrition and Development*, *10*(5).
8. Kumar, V., Biswas, A. K., Sahoo, J., Chatli, M. K., & Sivakumar, S. (2013). Quality and storability of chicken nuggets formulated with green banana and soybean hulls flours. *Journal of Food Science and Technology*, *50*(6), 1058–1068.
9. Landan, D., Colon, V. J., McIntosh, A. S., & Ramirez, F. C. (1997). Outcomes of pneumococcal bacteremia in cirrhotics. *GASTROENTEROLOGY*, *112*(4), A1313–A1313.
10. Lopez‐ Reyes, J. G., Spadaro, D., Gullino, M. L., & Garibaldi, A. (2010). Efficacy of plant essential oils on postharvest control of rot caused by fungi on four cultivars of apples in vivo. *Flavour and Fragrance Journal*, *25*(3), 171–177.
11. Madiouli, J., Sghaier, J., Lecomte, D., & Sammouda, H. (2012). Determination of porosity change from shrinkage curves during drying of food material. *Food and Bioproducts Processing*, *90*(1), 43–51.
12. Matazu, I. K., & Haroun, A. A. (2004). The effect of drying method on the nutrients and non-nutrients composition of the fruit of Hibiscus esculentus (Okra). *Nigerian Journal of Renewable Energy*, *11*, 9–13.
13. Morris, M. C., & Tangney, C. C. (2014). Dietary fat composition and dementia risk. *Neurobiology of Aging*, *35*, S59–S64.
14. Prasad, A., & Prasad, K. (2013). Studies on kinetics of moisture removal from spinach leaves. *International Journal of Agriculture and Food Science Technology*, *4*(4), 303–308.
15. Rahimmalek, M., & Goli, S. A. H. (2013). Evaluation of six drying treatments with respect to essential oil yield, composition and color characteristics of Thymys daenensis subsp. daenensis. Celak leaves. *Industrial Crops and Products*, *42*, 613–619.
16. Randhawa, M. A., Khan, A. A., Javed, M. S., & Sajid, M. W. (2015). Green leafy vegetables: a health promoting source. In *Handbook of fertility* (pp. 205–220). Elsevier.
17. Rao, Y., & Xiang, B. (2009). Determination of total ash and acid-insoluble ash of Chinese herbal medicine Prunellae spica by near infrared spectroscopy. *Yakugaku Zasshi*, *129*(7), 881–886.
18. Roshanak, S., Rahimmalek, M., & Goli, S. A. H. (2016). Evaluation of seven different drying treatments in respect to total flavonoid, phenolic, vitamin C content, chlorophyll, antioxidant activity and color of green tea (Camellia sinensis or C. assamica) leaves. *Journal of Food Science and Technology*, *53*(1), 721–729.
19. Schoch, T. J. (1964). Fatty substances in starch. Determination and removal. *Methods in Carbohydrate Chemistry*, *4*, 56–61.
20. Sellami, I. H., Rebey, I. B., Sriti, J., Rahali, F. Z., Limam, F., & Marzouk, B. (2012). Drying sage (Salvia officinalis L.) plants and its effects on content, chemical composition, and radical scavenging activity of the essential oil. *Food and Bioprocess Technology*, *5*(8), 2978–2989.
21. Sultan, T., Ahmed, A., Qayyum, A., Mumtaz, A., & Khalid, N. (2020). Effect of Buckwheat Supplementation on the Quality Parameters of Pasta. *Pakistan Journal of Agricultural Research*, *33*(3).