

Effect of particle size distribution on techno-functional properties of *Chenopodium album* (Bathua) powder

Priyanka Kundu

Lovely Professional University

Purna Gupta (✉ purna.gskuastj@gmail.com)

Lovely Professional University

Mukul Kumar

Lovely Professional University

Research Article

Keywords: *Chenopodium album*, emulsion capacity, foaming capacity, particle size, water solubility index

Posted Date: August 25th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1977506/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

With the growing population, demand and supply of nutrients are falling short and underutilized greens offer promising nutritive value to nourish the ever-increasing population. The present study aims to use bathua, an edible weedy crop as an extensive source of essential minerals and antioxidants having anti-microbial, anti-tumor, anti-inflammatory, hypotensive, anti-cancerous, contraceptive, odontalgic, and laxative properties. Being locally confined and perishable, there is a need to concentrate on its commercialization. For this, bathua leaves were dried at a temperature of 50°C and analysed with particle sizes 24, 36, 52, 76, 100, 200 and 300 BSS. A decrease in the bulk density (0.53 ± 0.01 to 0.24 ± 0.02 g/cm³), oil holding capacity (60.12 ± 0.02 to $16.02 \pm 0.04\%$), emulsion capacity and stability (23.99 ± 0.01 to $21.82 \pm 0.04\%$), (32.47 ± 0.02 to $19.12 \pm 0.02\%$), foam stability (3.97 ± 0.03 to $1.79 \pm 0.01\%$), tapped density (0.60 ± 0.01 to 0.29 ± 0.01 g/ml), and angle of repose (35.71 ± 0.01 to 26.56 ± 0.11) was observed as the particle size decreased, and an increase in the water holding capacity (12.94 ± 0.02 to 15.98 ± 0.02), water solubility index (7.27 ± 0.02 to 10.98 ± 0.02), foam capacity (1.81 ± 0.02 to $5.81 \pm 0.03\%$), swelling capacity (3.98 to $6.02 \pm 0.13\%$) and wettability (91 ± 0.57 to 222 ± 0.57) was observed. Results concluded that powdered form of bathua can be used as a functional ingredient in food formulations like pasta, nuggets, soups, RTS flat breads, biscuits.

1. Introduction

India has multifarious underutilized greens of promising nutritive value many of them are supple, adaptive and tolerant to adverse climatic conditions (Umerah and Nnam, 2019). As such can be raised comparatively at lower management costs even on poor marginal lands and are the cheapest source of nutrients. Still they are generally ignored due to lack of awareness and less popularization of technologies for their better utilization (Kamble and Jadhav, 2013). It is thus not surprising that we have used only one-third of the edible plant species which are available all around the world. There are in totality more than 5000 green leafy varieties available out of which only 1000 varieties are used for consumption in direct or indirect ways (Panda et al., 2015). In this study, we are addressing one such weedy green leafy vegetable, *Chenopodium album* often known by other names as bathua, pigweed, goosefoot, fat hen, vastukah, parupukkirai, chandanbetu and belongs to the family *Chenopodiaceae* (Pandey et al., 2016). The plant can even grow under stressful conditions like low or high rainfall, hot and humid weather conditions, making it versatile by nature (Yadav et al., 2007). The nutritive value is due to the presence of essential amino acids (like leucine, isoleucine, lysine, methionine, threonine, valine, tryptophan and phenylalanine), minerals like calcium, iron, zinc, phosphorous and potassium and, vitamins like Vit. A, Vit. C and Vit. B complex (Aman et al., 2016; Jhade et al., 2009). Being low in calories and high in dietary fibre, it has a unique ability to improve an individual's health profile (Sahu et al., 2020). Presence of various alkaloids, phenols, antioxidants (carotenoids, chlorophyll), saponins, phytosterols and flavonoids specifically kaempferol and quercetin that contributes towards its use in medicines and therapeutics was also seen (Kumar et al., 2007). Moreover, the presence of phytochemicals like glycosides, trigonelline, chenodine is responsible for its pharmacological activation in treating cardiac

disease, breast cancer, liver disorders, abdominal pain, piles and blood purification (Yadav et al., 2007) and thus show antimicrobial, anti-tumour, anti-inflammatory, hypotensive, anti-cancer, contraceptive, odontalgic and laxative property (Mousavi et al., 2005). Some studies also supported the cooling and sedative properties of the plant (Buragohain et al., 2013). In the present work, *chenopodium album* leaves powder was characterized and compared on the basis of particles size by sifting through the sieve shaker to study the effect of varied particle sizes on the hydration or techno-functional properties of powder to explore its multidimensional uses in food and pharmaceutical industries.

2. Materials And Methodology

Freshly harvested leaves of *chenopodium album* were collected from the agricultural land of Lovely Professional University, Jalandhar, Punjab. The leaves were separated and washed followed by hot air drying at 50⁰C for 8 hours until the moisture content has reached a constant value of up to 6% - 8% on wet basis. Dried leaves were then grinded to obtain coarse powder that was then sifted through sieve of different sizes (24BSS, 32BSS, 52BSS, 72BSS, 100BSS, 200BSS, 300BSS) for segregation on the basis of particle size based on which different properties of the powder were analyzed.

Physico-chemical Analysis

Firstly, freshly harvested leaves were characterized for their proximate composition (Table 1). Bulk and tapped density are then characterized as functional properties, evaluation of which is important with respect to packaging of powders based on pores and void size, and also utilization in chemical and pharmaceutical industry (Fazaeli et al., 2012). These attributes were calculated as per the method given by Bai *et al.*, 2006 and Jinapong, and Jamnong, 2008. Hausner ratio and carr index was determined as a ratio of bulk density and tapped density. Hausner ratio is related to flow-ability of powder. Carr index is the indication on compressibility of powder particle like if Carr index is between 5 to 15% this means powder is having excellent flow ability but if carr index is above 25% this indicate poor flow-ability of powder. We have calculated the flowing property on the basis of HR criteria given below:

1.0 < HR < 1.1 = Free flowing powder; 1.1 < HR < 1.25 = Medium flowing powder; 1.25 < HR < 1.4 = Difficult flowing powder; HR > 1.4 = Very difficult flowing powder

$$\text{Hausner ration (HR)} = \frac{\rho_T}{\rho_B} ; \text{Carr index (CI)} = \frac{\rho_T - \rho_B}{\rho_T} \times 100$$

where, ρ_T = Tapped density, ρ_B = Bulk density

Carr index criteria	Angle of Repose
CI < 10% = Excellent flow	$\theta < 30^\circ$ = Excellent flow
CI = 10–15% = Good flow	$\theta = 31^\circ - 35^\circ$ = Good
CI = 16–20% = Fair flow	$\theta = 36^\circ - 40^\circ$ = Fair
CI = 21–25% = Passable flow	$\theta = 41^\circ - 45^\circ$ = Passable
CI = 26–31% = Poor	$\theta = 46^\circ - 55^\circ$ = Poor
CI = 32–37% = Very poor	$\theta > 56^\circ$ = Very poor

The angle of repose is a slope which is formed by the powder without collapsing. It was determined by the method given by Chen *et al.*, in 2015. Swelling and wettability are the hydration properties and are evaluated based on the methods given by Raghavendra et al., 2004 and Reddy et al., 2014 whereas for measuring the water holding capacity and water solubility index the formulations given by Wu *et al.*, 2010 was followed. Water holding capacity was calculated on the basis of wet sediments while water solubility index was calculated on the basis of difference in weight of dried supernatant and initial sample (Kha et al., 2010). All the powder samples were poured in the 7 pre-weighted empty centrifuge tubes separately and dispersed in 30ml distilled water followed by mixing through vortex mixture. After that the dispersion was allowed to stand for 30 min in a water bath at 30°C. Subsequently, the dispersion was centrifuged at 4500 rpm for 10 min. After that, the supernatants were carefully poured into petri dishes for drying at 105°C for 20 min in an oven, while the sediments were weighed as such (Zhao et al., 2009). Emulsion capacity and stability as well as oil holding capacity was measured with the method provided by Chiu *et al.*, 2007. Foam foaming stability was determined with the method given by (Ven et al., 2002).

Statistical Analysis

One-way ANOVA was used for statistical analysis of the experimental data. Results were expressed as mean value $\pm$ standard deviation. Means were compared by univariate variable analysis. Statistical significance was considered when $P < 0.05$.

3. Results And Discussion

The functional properties of different food powders depend mainly on the size of the particles of the powder. It has been observed that as the particle size decreased, the bulk density and the tapped density also decreased from 0.53 to 0.24g/cm³ and (0.60 to 0.29g/ml) (Table 2a, Fig. 1A), whereas the water holding capacity and water solubility index of powder significantly increased (Fig. 2B). This might be due to larger contact surface, lesser pore space between the particles and due to exposure of hydrophilic groups which leads to maximum integration of water and increased solubility with respect to surface energy and surface area (Zhang *et al.*, 2012, and Phoungchandang and Sertwasana, 2010). Similar results were reported by Jiang *et al.*, in 2017 when they studied the effect of superfine grinded leaf

powder on the properties of *Vaccinium bracteatum* Thunb. (VBT). Both the properties are linked to the particle interactions and played a significant role in describing the flowing property of powder (Wang *et al.*, 2015). The HR index also shows the behavior of powder based on bulk density. It is also an indication of the friction conditions between the powder articles. The angle of repose showed a reduction with respect to decreased particle size (35.71° to 26.56°) (Fig. 1B) and showed a greater impact on the flow ability and fluidity of powders (Enferad *et al.*, 2021). Smaller size particles filled the inter-particle voids and improve the fluidity and also favors greater water retention and solubilization (Ileleji *et al.*, 2008). Similar observations were obtained by Chen *et al.*, 2015 when they studied the effect of superfine grinding on physicochemical properties, antioxidant activity and phenolic content of red rice (*Oryza Sativa L.*). Similarly, the particle size distribution had repercussions on oil holding capacity. As the particle size is reduced from 24 British Sieve Size to 300 BSS so did the oil holding capacity from 60.12 to 16.02 (Fig. 2A, Table 2b). This might be due to the damage in the structure of powder particles and increased exposure of hydrophilic groups in larger size particles of coarse powder which leads to the physical entrapment of oil (Kaushal *et al.*, 2012 and Aremu *et al.*, 2007). The foaming capacity and stability showed an inverse relationship and are generally required to improve the consistency, appearance and texture of food (Kaur *et al.*, 2006). Low foaming stability (3.97 to 1.79%) on the other hand can be attributed to highly ordered globular proteins which resist denaturation (Lattimer and Haub, 2010) whereas foaming capacity increased from 1.81–5.81% with an increase in particle size (Fig. 3A, Table 3). These results are in accordance with Mugova *et al.*, 2021 on armoured cricket (*Acanthopplus discoidalis*) flour. The emulsion capacity (23.99 to 21.82%) and emulsion stability (32.47 to 19.12%) also significantly affected by a decrease in particle size (Fig. 3B, Table 3) (Yu *et al.*, 2007). The smallest the particle size maximum is the emulsion capacity which might be due to greater surface area exposure to oil or water which leads to the maximum stability of emulsion as well and increases its scope to be used in cakes and desert preparations. Similar findings were also reported by Mohamed *et al.*, 2012. Swelling capacity is directly linked to the water holding capacity of powder and showed a similar trend as observed in the case of water holding capacity (Benjamin *et al.*, 2017). Swelling capacity rises with a decreases in particle size (Fig. 4A, Table 2b) and is shows the amount of associative forces present in the powder especially starch granules and hydration capacity of starches (Adebawale *et al.*, 2012 and Tortoe *et al.*, 2017). According to Sharma *et al.*, 2012 the functional attribute is highly dependent on particle size as smaller particle size requires more time to achieve complete wettability and form bubbles due to the air space in between the particles and deformed structures. Wettability has a direct relationship with the dissolution of powder components (Juliuanti *et al.*, 2015). Hence powder with higher solubility will require less time to get completely wet and resulted in reduced wetting time and vice versa (Fig. 4B, Table 3). From the results it can be concluded that *Chenopodium album* possesses the properties that helps in its stabilization and can be preserved in powdered form for its further utilization in food, pharmaceutical and medicinal industry. The exploitation of these traditional greens can provide us with a way to deal with food security and malnutrition as well.

Conclusion

To meet the nutritional requirement and to curb the onset of different diseases one has to explore varied unexplored sources. These unexplored weeds can play important role in a more diversified and sustainable food production system that can serve food with more nutrient density and diversity. The present work represents the effect of powder particle size on its techno-functional properties of bathua for its further utilization in food as in extruded products, roasted and fried snacks, breads, pharma and medicinal industry. The analyzed food powder was characterized on the basis of different physical properties like particle size, bulk and tapped density, wettability, swelling capacity, foam capacity and foam stability, oil capacity and stability, emulsion stability. The study showed a statistically significant influence on the analyzed physical properties.

Abbreviations

BSS: British Sieve Shaker

°C: degree Celsius

g/ml: gram per milliliter

EC: Emulsion Capacity

ES: Emulsion Stability

FS: Foam Stability

FC: Foam stability

OHC: Oil Holding Capacity

WHC: Water Holding Capacity

WSI: Water Solubility Index

HR: Hausner ratio

GAE: Gallic Acid Equivalent

%: percent

Declarations

Conflit of interest: The study holds no conflict of interest

Authors' contributions and Declaration– The study is solely reviewed and written by the first, corresponding and Co-author author. And has not been submitted anywhere for publication. The paper is

written by the first and corresponding author and corrections and formatting is done by the corresponding author and co-author. Also online grammarly help was taken for checking grammatical errors.

As a corresponding author, I confirm that the manuscript has been read and approved for submission by me and my co-author. I hope that you find the manuscript suitable for publication and look forward for hearing from you in due course.

The main findings of this paper highlights the suitability of using weed (*chenopodium*) in food, pharmaceutical and medicinal industry products because of their anti- cancerous effect. During recent years nothing much has been discussed to promote bathua in different forms in food and thus there is a need to show their positive effect for better utility and for lesser use of preservatives.

Funding Declaration: The paper has not been funded by any external agency. We are thankful to Lovely Professional University for allowing us to work and grow a weedy crop in the agricultural field.

Availability of data and material – The data is collected from different sources as such no copyright permission is required. All the tables and figures are made according to the results obtained on particular weed.

References

1. Akindahunsi, A. A and Salawu, S. O. (2005). Phytochemical screening and nutrient and anti-nutrient composition of selected tropical green leafy vegetables. *African Journal of Biotechnology*, 4 497-501
2. Adebowale, A., Sanni, S. A., Adegunwa, M. O., Olatunde, G. (2012). Functional properties and biscuit making potentials of sorghum- wheat flour composite. *American Journal of Food Technology*. 7(6), 372–379.
3. Aman, S., Mazumder, A., Gupta, U. K. and Nayak, A. (2016). Pharmacological activities of *chenopodium album*- A Review
4. Aremu, M. O., Olaofe, O. and Akintayo, E.T. (2007). Functional properties of some Nigerian varieties of legume seed flour concentration effect on foaming and gelation properties. *Journal of Food Technology*. ;5(2):109–115.
5. Bai, Y. X. and Li, Y. F. (2006). Preparation and characterization of cross-linked porous cellulose beads. *Carbohydrate Polymer*, 64, 402-407.
6. Buragohain, J., Singh, V. B., Deka, B. C., Jha, A. K., Wanshnong, K and Angami, T. (2013). Collection and evaluation of some underutilized leafy vegetables of Meghalaya. *Indian Journal of Hill Farming*, 26(2) 111-115.
7. Benjamin, K.P., Augustin, G., Armand, A. B. and Moses, M.C., (2017). Effect of ageing on the physico-chemical and functional characteristics of maize (*Zea mays* L.) flour produced by a company at Maroua (Far North of Cameroon), during storage. *African Journal of Food Science*., 11, 134–139.

8. Ven, C.V.D., Gruppen, H. De., Bont, D.B.A. (2002). Voragen correlation between biochemical and foam forming and stabilizing ability of whey and casein hydrolysates *Journal of Agriculture and Food Chemistry*. 50, pp. 2938-2946
9. Chen, Y., Zhang, B. C., Sun, Y. H., Zhang, J. G., Sun, H. J, Wei, Z. J. (2015). Physicochemical properties and adsorption of cholesterol by okra (*Abelmoschus esculentus*) powder. *Journal of Food Function*. 6: 3728–3736
10. Enferad, S., Petit, J., Gaiani, C., Falk, V., Burgain, J., Kiesgen De Richter, S., and Jenny, M. (2021). Effect of particle size and formulation on powder rheology. *Particulate Science and Technology*, 39(3), 362-370.
11. Fazaeli, M., Emam-Djomeh, Z., Kalbasi-Ashtari, A., and Omid, M. (2012). Effect of process conditions and carrier concentration for improving drying yield and other quality attributes of spray dried black mulberry (*Morus nigra*) juice. *International Journal of Food Engineering*, 8(1), 1.
12. Goula, A. M., Adamopoulos, K.G. (2003). Spray drying performance of a laboratory spray dryer for tomato powder preparation. *Drying Technology*, 21, 1273–1289.
13. Gupta, S., and Prakash, J. (2011). Nutritional and sensory quality of micronutrient-rich traditional products incorporated with green leafy vegetables. *International Food Research Journal*, 18(2).
14. Ileleji, K. E., and Zhou, B. (2008). The angle of repose of bulk corn stover particles. *Powder Technology*. 187: 110–118.
15. Jhade, D., Paarakh, P. M., and Gavani, U. (2009). "Isolation of phytoconstituents from the leaves of *Chenopodium album* Linn", *Journal of Pharmacy Research*. 2 (7), pp. 1192-1193.
16. Jiang, L., Xu, Q. X., Qiao, M., Ma, F. F., Thakur, K., and Wei, Z. J. (2017). Effect of superfine grinding on properties of *Vaccinium bracteatum* thumb. leaves powder. *Food Science and Biotechnology*, 26(6), 1571-1578.
17. Jinapong, N., Suphantharika, M., and Jamnong, P. (2008). Production of instant soymilk powders by ultrafiltration, spray drying and fluidized bed agglomeration. *Journal of Food Engineering*, 84(2), 194–205.
18. Julianti, E., Rusmarilin, H., and Yusraini, E. (2015). Functional and rheological properties of composite flour from sweet potato, maize, soybean and xanthan gum. *Journal of the Saudi Society of Agricultural Sciences*, 16(2), 171-177.
19. Kamble, V. S and Jadhav, V. D. (2013). Traditional leafy vegetables: a future herbal medicine, *International Journal of Agricultural and Food Science*, 3(2) 56-58
20. Kaur, M., Sandhu, K. S. and Singh, N. (2006). Comparative study of the functional, thermal and pasting properties of flours from different field pea (*Pisum sativum* L.) and pigeon pea (*Cajanus cajan* L.) cultivars. *Food Chemistry*. 104: 259–267.
21. Kaushal, P, Kumar, V., Sharma, H. K. (2012). Comparative study of physico-chemical, functional, anti-nutritional and pasting properties of taro (*Colocasia esculenta*), rice (*Oryza sativa*), pigeon pea (*Cajanus cajan*) flour and their blends. *LWT-Food Science and Technology*. 48: 59–68.

22. Kha, T. C., Nguyen, M. H., Roach, P. D. (2010). Effects of spray drying conditions on the physicochemical and antioxidant properties of the Gac (*Momordica cochinchinensis*) fruit aril powder. *Journal of Food Engineering*. 98:385– 392.
23. Kim, E. H. J., Chen, X. D., Pearce, D. (2002). Surface characterization of four industrial spray-dried powders in relation to chemical composition, structure and wetting property. *Colloids and Surfaces B:Biointerfaces*, 26, 197–212
24. Kumar, R., Mishra, A. K., Dubey, N. K., Tripathi, Y. B. (2007). Evaluation of *Chenopodium album* oil as a potential source of antifungal, antiaflatoxic and antioxidant activity. *International Journal of Food Microbiology*, 115:159-64.
25. Lattimer, J. M. and Haub, M. D. (2010). Effects of dietary fiber and its components on metabolic health. *Nutrients*. 2: 1266-1289.
26. Mohamed, F. A., Ahmed, I. A.M., Ahmed, S. O., Babiker, E. E. (2012). Nutritional and functional characterization of defatted seed cake flour of two sudanese groundnut (*Arachis hypogaea*) cultivars. *International Food Research Journal*. 19(2):629-637.
27. Mousavi, T., Asadi, N. and Tebyanian, M. (2005). Study of *Chenopodium album* allergenic extract to induce allergic asthma in murine model. *Iranian Journal of Immunology*, 23:166-71.
28. Mugova, A. K., Zvidzai, C.J., Musundire, R. (2021). Techno-functional Properties of Armoured Cricket (*Acanthopplus discoidalis*) Flour. *Scholars Journal of Engineering and Technology*, 8, 102-112. DOI: 10.36347/sjet.2021.v09i08.001.
29. Pandey, S. and Gupta, R. (2014). Screening of nutritional, phytochemical, antioxidant, antibacterial activity of *Chenopodium album*. *Journal of Pharmacognosy and Phytochemistry*, 3, 1-9.
30. Panda, T., Mishra, N., Pradhan, B. K and Mohanty, R. B. (2015). Diversity of leafy vegetables and its significance to rural households of Bhadrak district, Odisha, India, *Scientia Agriculturae*, 11(3):114-123.
31. Phoungchandang, S. and Sertwasana, A. (2010). Spray-drying of ginger juice and physicochemical properties of ginger powders, *Science Asia*. 36:40–45.
32. Raghavendra, S. N., Rastogi, N. K., Raghavarao, K. S. M. S., and Tharanathan, R. N. (2004). Dietary fiber from coconut residue: effects of different treatments and particle size on the hydration properties. *European Food Research and Technology*, 218(6), 563-567.
33. Reddy, R. S., Ramachandra, C.T., Hiregoudar, S., Nidoni, U., Ram, J. and Kammar, M. (2014). Influence of Processing Conditions on Functional and Reconstitution Properties of Milk Powder Made from Osmanabadi Goat Milk by Spray Drying. *Small Ruminant Research*. 119, 130–137.
34. Sahu, M. P., Kewat, M.L., Jha, A. K., Sharma, J. K., Sondhia, S. (2020). Identification of Problematic Weeds in Chickpea Crop in Jabalpur District of Madhya Pradesh, India. *International Journal of Current Microbiology and Applied Sciences*. 9(9): 973-977.
35. Shafi, M., Baba, W. N., Masoodi, F. A. and Bazaz, R. (2016). Wheat-water chestnut flour blends: Effect of baking on antioxidant properties of cookies. *Journal of Food Science and Technology*, 53(12), 4278–4288.

36. Sharma, M., Kadam, D. M., Chadha, S., Wilson, R., Gupta, R. K. (2012). Influence of particle size on physical and sensory attributes of mango pulp powder. *International Agrophysics*. 27(3):323-328.
37. Tortoe, C., Akonor, P. T., Koch, K., Menzel, C. and Adofo, K. (2017). Physicochemical and functional properties of flour from twelve varieties of Ghanaian sweet potatoes. *International Food Research Journal*, 24(6): 2549-2556.
38. Umerah, N. N., and Nnam, N. M. (2019). Nutritional composition of neglected underutilized green leafy vegetables and fruits in South East geo-political zone of Nigeria. *Asian Food Science Journal*, 1-17.
39. Yasumatsu, K., Sawada, K., Moritaka, S. S., Toda, J. and Ishii, K. (1972). Whipping and emulsifying properties of soybean products. *Journal of Agricultural and Biological Chemistry*. 36 (5): 719-724.
40. Yousef, S., Emam-Djomeh, Z. and Mousavi, S. M. (2010). Effect of carrier type and spray drying on the physicochemical properties of powdered and reconstituted pomegranate juice (*Punica Granatum* L.). *Journal of Food Science and Technology*, 48(6), 677–684.
41. Yu, J., Ahmedna, M. and Goktepe, I. (2007). Peanut protein concentrates: production and functional properties as affected by processing. *Food Chemistry* 103:121– 129
42. Yadav, N., Vasudeva, N., Singh, S., and Sharma, S. K. (2007). Medicinal properties of genus *Chenopodium* Linn. *Natural Product Radiance*. 6(2):131-134.
43. Zhao, X.Y., Yang, Z. B., Gai, G. S. and Yang, Y.F. (2009). Effect of superfine grinding on properties of ginger powder. *Journal of Food Engineering*, 2, 217-222.

Tables

Table.1. Proximate composition of fresh *Chenopodium album* leaves

Components name	Concentration
Moisture	87.7± 0.06 %
Ash	2.09±1.02 %
Protein	3.1± 0.03 %
Carbohydrate	5.26 ± 0.29 %
Total phenolic content	301.41±0.30 mg GAE/100g
Total flavonoids	336.35±0.25 mg/100g
Antioxidant activity	91.18±0.14%
Ascorbic acid	75 ±0.57 mg/100g
β- Carotene	1692.41±0.48 mg/100g
Chlorophyll a	1.18±0.07 mg/g
Chlorophyll b	0.91±0.09 mg/g
Total Chlorophyll	2.09±0.01 mg/g
Oxalates	14.02±0.25 g/100g
Saponin	12.45±0.07 µg/100g

Table.2a. Effect of particle size on the physical properties of *chenopodium album* leaves powder

Particle size (microns)	Bulk density(g/cm ³)	Tapped density(g/ml)	Carr index %	HR index	Angle of repose (°)
625	0.53±0.01 ^g	0.60±0.01 ^g	7.54±0.11 ^f	1.02±0.01 ^a	35.71±0.01 ^e
416	0.49±0.03 ^f	0.55±0.01 ^f	6.89±0.02 ^e	1.03±0.01 ^a	33.69±0.04 ^d
267	0.44±0.01 ^e	0.49±0.02 ^e	6.01±0.03 ^e	1.04±0.01 ^a	30.11±0.01 ^c
208	0.40±0.02 ^d	0.44±0.02 ^d	5.21±0.02 ^d	1.11±0.02 ^b	30.01±0.01 ^c
150	0.35±0.02 ^c	0.39±0.02 ^c	4.56±0.05 ^c	1.26±0.01 ^c	26.69±0.04 ^b
75	0.31±0.02 ^b	0.35±0.01 ^b	3.91±0.02 ^b	1.37±0.02 ^d	26.66±0.04 ^a
50	0.24±0.02 ^a	0.29±0.01 ^a	2.86±0.04 ^a	1.52±0.01 ^e	26.56±0.11 ^a

***Mean ± SD (n=3).** Values within a row with different subscripts showed significant difference (p<0.05) where, HR is the horse ratio

Table.2b. Effect of particle size on the functional properties of *chenopodium album* leaves powder

Particle size (microns)	WHC(g/g)	OHC (%)	WSI (%)	Swelling capacity (%)
625	12.94±0.02 ^a	60.12±0.02 ^g	7.27±0.02 ^a	3.98±0.01 ^a
416	13.42±0.03 ^b	56.23±0.02 ^f	7.74±0.01 ^b	4.24±0.01 ^b
267	13.92±0.02 ^c	49.11±0.02 ^e	8.34±0.03 ^c	4.67±0.02 ^c
208	14.37±0.03 ^d	41.15±0.02 ^d	8.96±0.01 ^d	4.99±0.01 ^d
150	14.96±0.02 ^e	33.11±0.02 ^c	9.43±0.04 ^e	5.17±0.01 ^e
75	15.38±0.01 ^f	25.04±0.03 ^b	10.01±0.03 ^f	5.74±0.01 ^f
50	15.98±0.02 ^g	16.02±0.04 ^a	10.98±0.02 ^g	6.02±0.01 ^g

***Mean ± SD (n=3)**

Values within a row with different subscripts showed significant difference (p<0.05), where WHC is water holding capacity, OHC is oil holding capacity and WSI is water solubility index

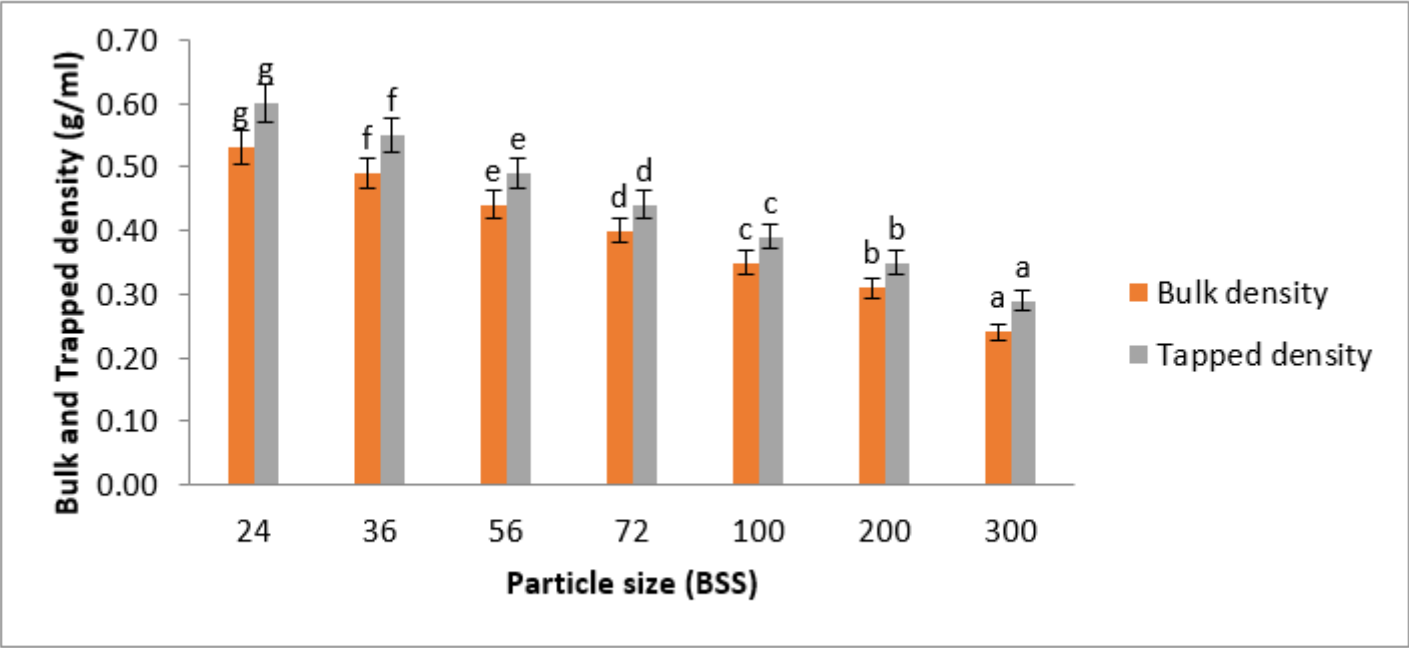
Table.3. Effect of particle size on the functional properties of *chenopodium album* leaves powder

Particle size (microns)	EC (%)	ES (%)	FC (%)	FS (%)	Wettability (Sec)
625	23.99±0.01 ^g	32.47±0.02 ^g	1.81±0.02 ^a	3.97±0.03 ^g	91±0.57 ^a
416	23.57±0.01 ^f	30.81±0.02 ^f	1.98±0.04 ^b	3.29±0.06 ^f	95±0.57 ^b
267	23.16±0.03 ^e	28.58±0.01 ^e	3.11±0.09 ^c	3.12±0.04 ^e	121±0.57 ^c
208	22.82±0.03 ^d	25.55±0.04 ^d	3.45±0.05 ^d	2.61±0.06 ^d	187±1.15 ^d
150	22.55±0.04 ^c	23.19±0.04 ^c	5.22±0.01 ^e	2.16±0.08 ^c	198±1.15 ^e
75	22.09±0.05 ^b	21.19±0.03 ^b	5.46±0.02 ^f	1.89±0.02 ^b	211±1.15 ^f
50	21.82±0.04 ^a	19.12±0.02 ^a	5.81±0.03 ^g	1.79±0.01 ^a	222±0.57 ^g

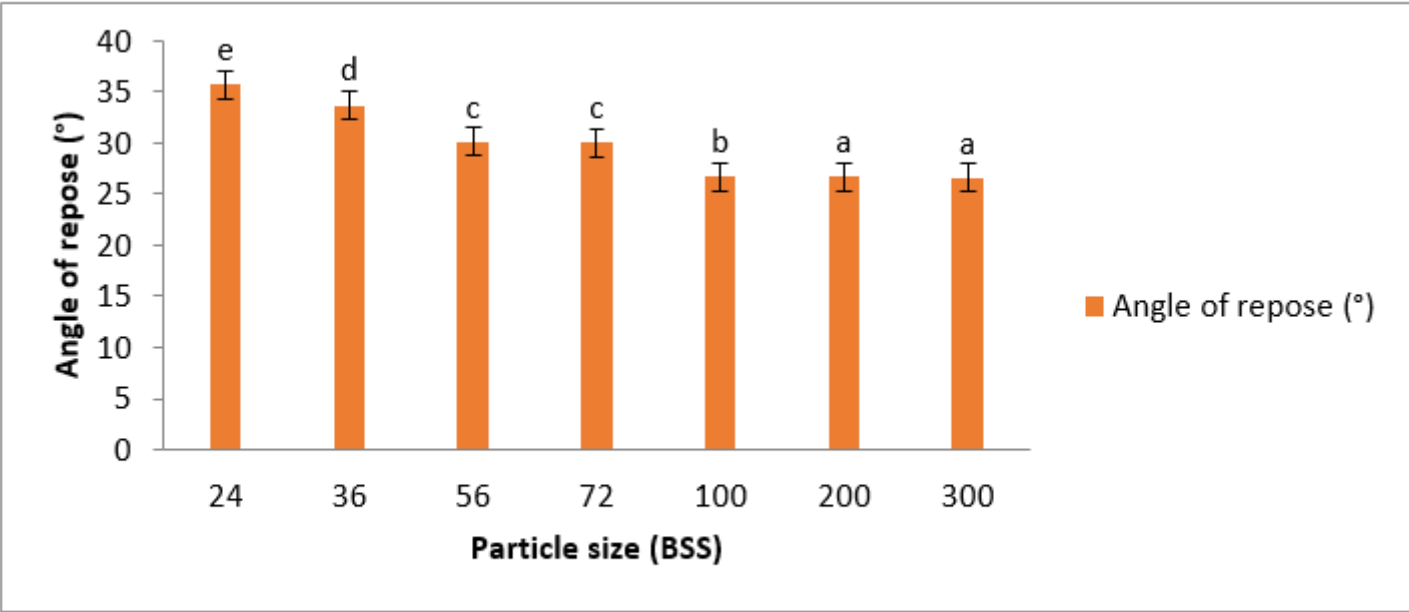
***Mean ± SD (n=3)**

Values within a row with different subscripts showed significant difference ($p<0.05$) where, EC is the emulsion capacity, ES is the emulsion stability, FC is the foam capacity and FS is the foam stability

Figures



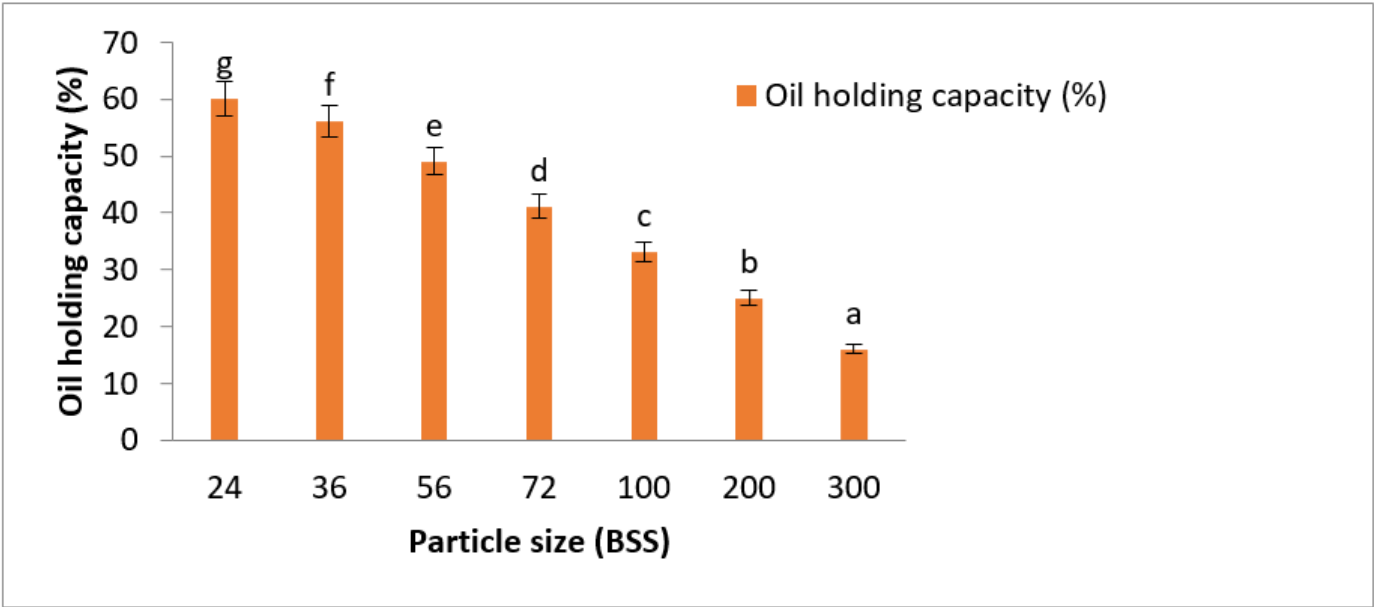
(A)



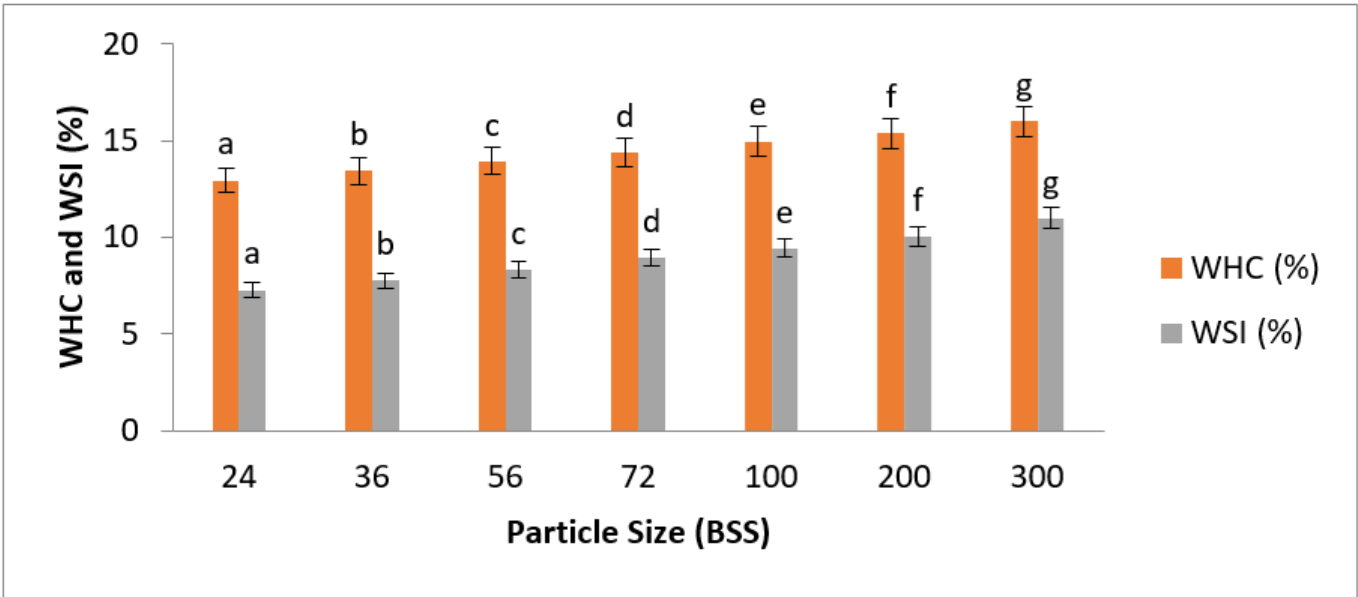
(B)

Figure 1

Effect of different particle size on bulk density, tapped density (A) and angle of repose (B) of *Chenopodium album* leaves powder



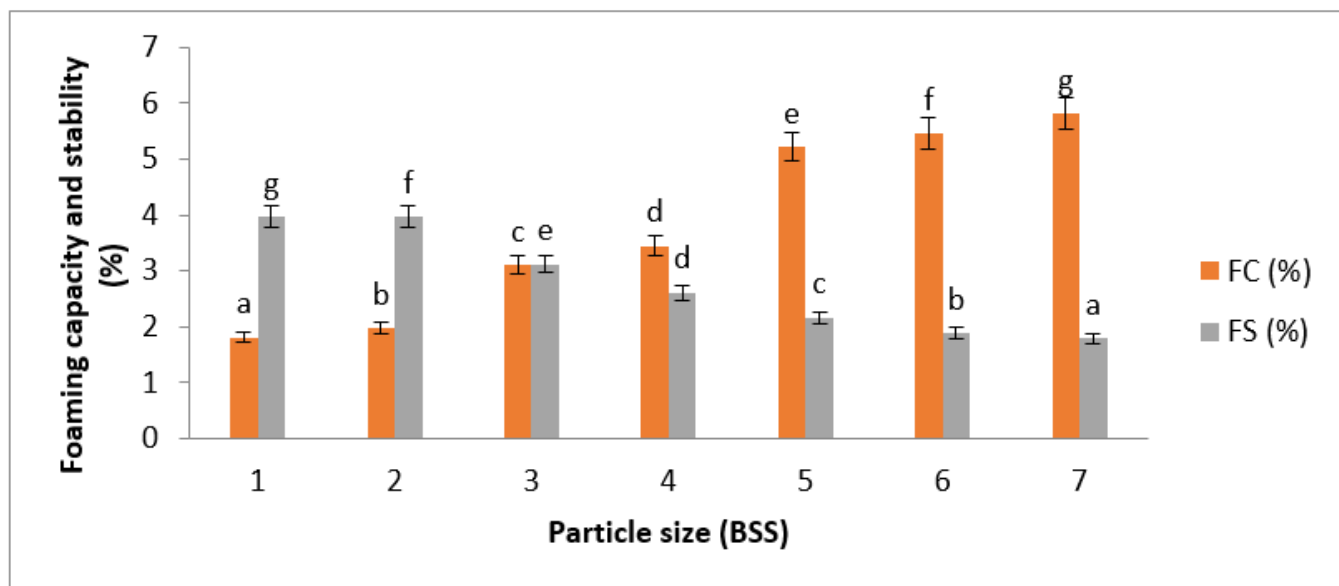
(A)



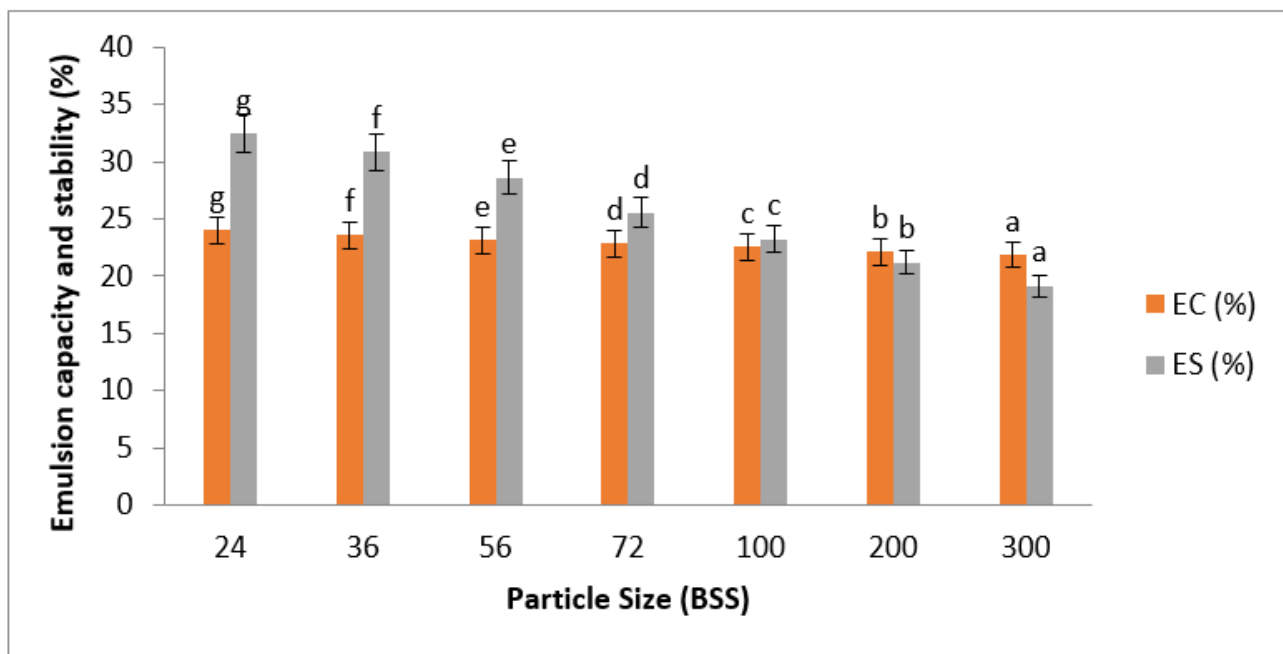
(B)

Figure 2

Effect of particle size of *Chenopodium album* leaves powder on oil holding capacity (A) and water holding capacity and water solubility index (B)



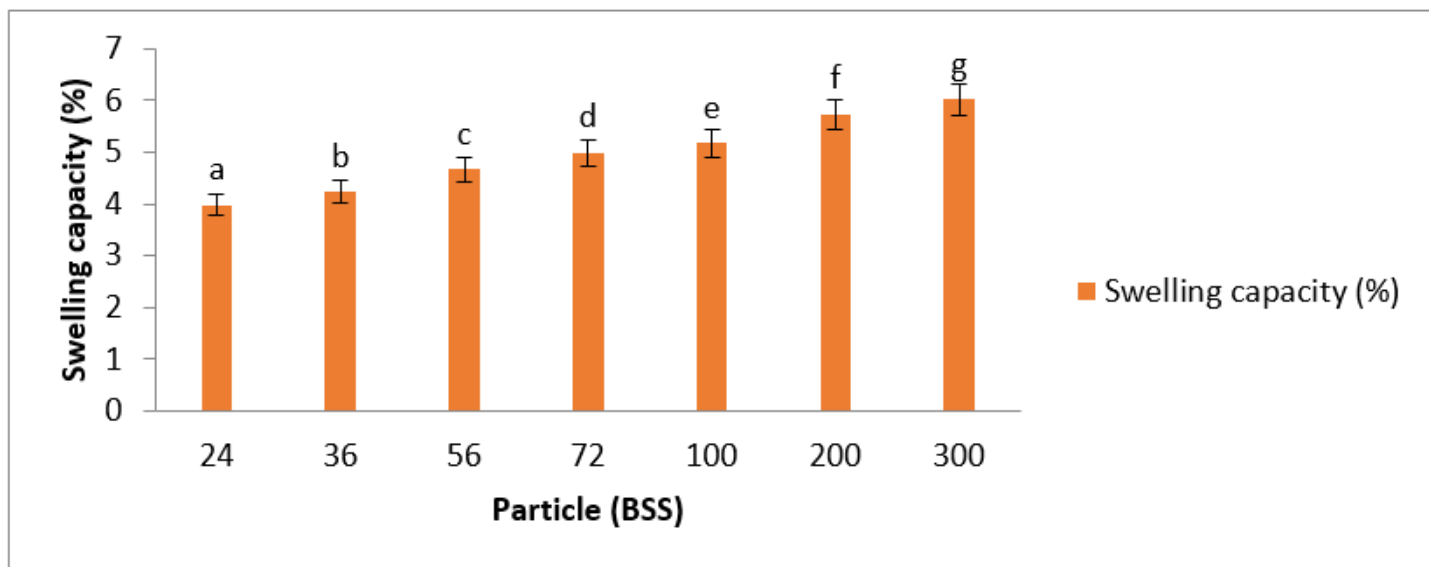
(A)



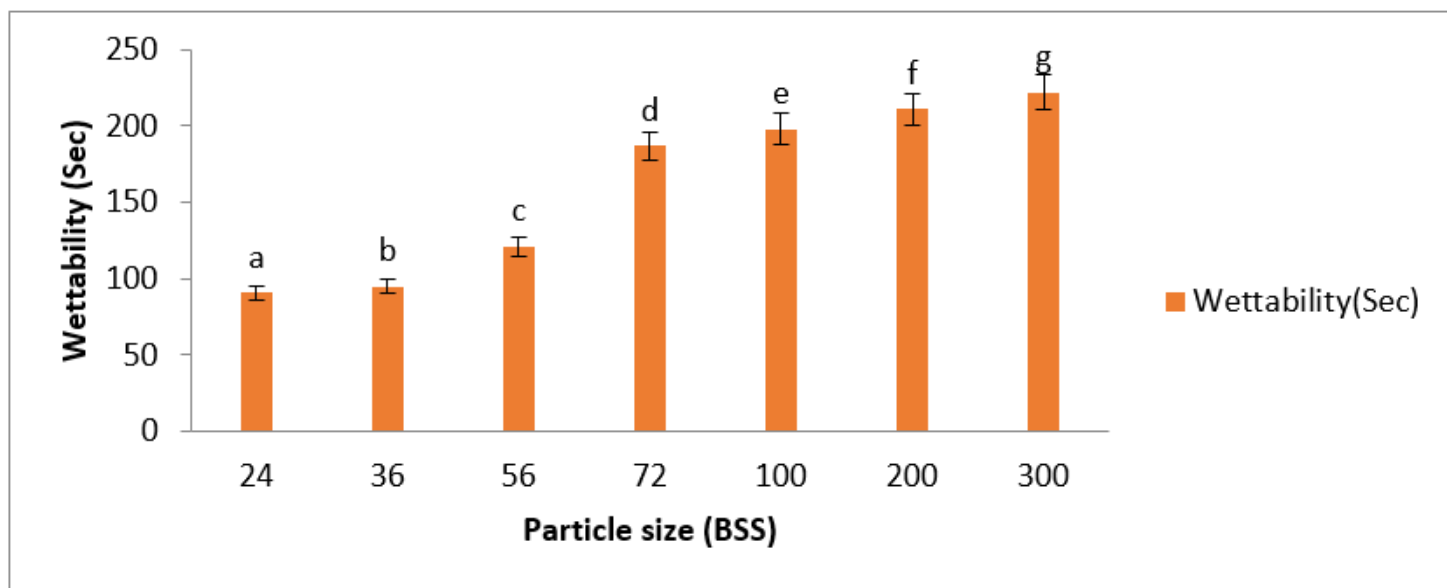
(B)

Figure 3

Effect of particle size on foam capacity and stability (A), emulsion capacity and stability (B) of *Chenopodium album* leaves powder



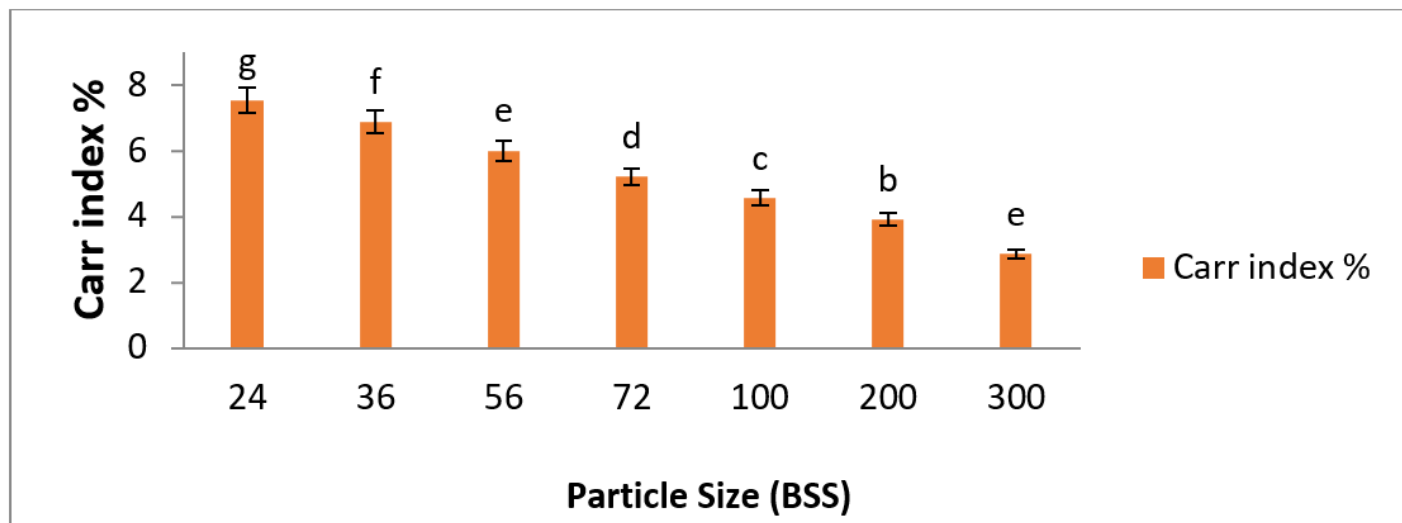
(A)



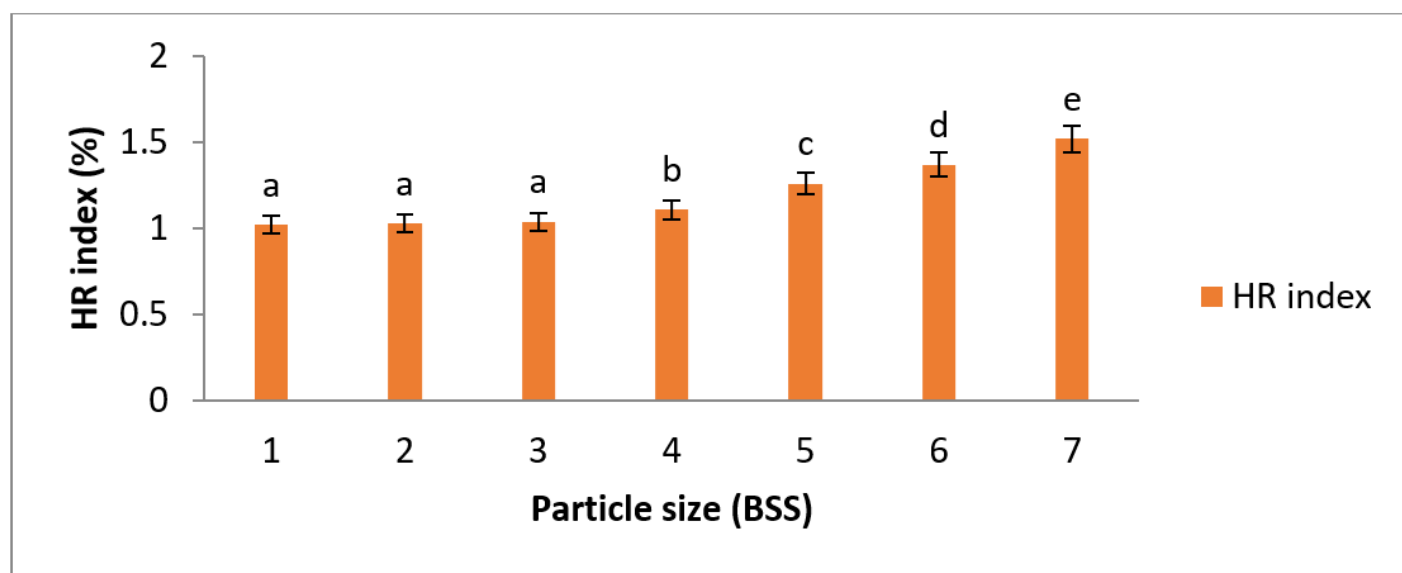
(B)

Figure 4

Effect of particle size on powder Swelling capacity (A) and Wettability (B) of *Chenopodium album* leaves



(A)



(B)

Figure 5

Effect of particle size on Carr index (A), HR index (B) of *Chenopodium album* leaves powder