

Effect of Storage on Biochemical properties and Bioactive Potential of Mix Fruit Juice Powder Fortified with Carambola Bagasse

ABSTRACT

This research was conducted with an aim to assess the effect of storage on physicochemical properties and bioactive potential of mix fruit juice powder fortified with carambola bagasse. Carambola-guava mix fruit juice powder fortified with carambola bagasse powder was prepared by adding 5% carambola bagasse, 35% carambola juice, 35% guava juice and 25% maltodextrin (MD) followed by spray drying at inlet air temperature 180°C. and feed flow rate (20-24 hour). Samples were sealed in plastic pouches and stored under ambient conditions for 90 days. The purpose of this study is investigated effect of parameters during storage. The significantly was found increase moisture, TSS and Water activity, Vitamin C, Antioxidant, Crude fiber, Total phenol, Total carotenoids, Solubility, Overall acceptability reduced during the storage periods respectively.

Keywords: - *Carambola Bagasse, inlet air temperature, mix juice, maltodextrin, parameters.*

1. INTRODUCTION

Fruit powders have a wide range of applications in the food industry as flavouring and functional ingredients [1]. The global market size of fruit powders is expected to reach \$21.5 billion by 2026 as compared to \$14.3 billion in 2021 [2]. Compared with fresh fruits, fruit powders are storage stable, highly portable, cost-effective and need less care during storage and transportation [3]. However, most fruit powders are hygroscopic in nature and may absorb moisture from the environment over the time, resulting in changes in their physico-chemical properties [4,5]. Water activity (a_w) plays an important role in maintaining the shelf-life of powders. When it exceeds the critical level, the fruit powder transitions from a glassy state to a rubbery state and becomes sticky [6]. There are several types of inter-particulate interactions, such as liquid bridges, solid bridges, mechanical interlocking, electrostatic attraction, and van der Waals forces that contribute to the stickiness of food powders [7]. However, these interactions vary in strength from the strongest (solid bridges, liquid bridges) to the weakest (van der Waals force, and electrostatic attraction) [8]. Under the influence of external factors, van der Waals forces, electrostatic forces, and liquid bridges increase particle contact which further results in elastic deformation, plastic deformation, and solid bridges [9].

The residual fruit powders on food processing equipment surfaces pose a challenge for dry sanitation protocols which aim to remove these residues following a production shift [10,11]. Many low moisture food production facilities employ dry sanitation, which primarily relies on physical removal strategies such as brushing, vacuuming, and scraping [12]. While the efficacy of wet sanitation procedures is relatively well understood [13], the governing variables and efficacy of physical removal strategies have been less well described. Therefore, it is important to investigate the factors influencing the efficacy of brushing to optimize dry sanitation protocols and schedules. The objective of this research is to investigate how the physicochemical properties and residence time of various fruit powders on surfaces impact the efficiency of dry-cleaning activities.

The starfruit is a denote as miner fruit crop but its consumed two stage fruit, when is still green or unripe, it can be used in savory dishes and usually often cooked or pickled and ripens (turn yellow), it is enjoyed as a sweet and juicy fruit. starfruit botanically known as *Averrhoa carambola* and family oxalidaceae, is a very adaptable fruit with a variety of culinary and maybe therapeutic use [14] Star fruit is a great option for individuals who are watching their calories because it is low in calories and fat and high in fiber and water. Vitamin B, B-complex, and C [15] as well as iron, salt, potassium, and a number of antioxidants, polyphenols, and flavonoids are all abundant in it. Significant antioxidant and antibacterial activity is found in star fruit [16]. Fruit consumption has been linked to a lower risk of noncommunicable diseases (NCDs) and undernutrition instances [17,18].

A common fruit in tropical and subtropical regions is the guava (*Psidium Guajava*). The Myrtaceae family includes it. The fruit's composition is 20% dry matter, 1% ash, 0.7% fat, 1.5% protein, and 80% moisture [19]. Along with beta-carotene, thiamine, riboflavin, niacin, and pantothenic acid, guavas are significant sources of ascorbic acid, or vitamin C. It also has a considerable quantity of sodium, potassium, calcium, iron, and phosphorus. Guava's high concentration of antioxidant pigments, such as carotenoids and polyphenols, enhances its nutritional value. These diverse bioactive nutrients are important components of conventional treatments for several diseases, including obesity, type 2 diabetes, diarrhea, and other health issues [20].

It has been reported that bagasse left after carambola juice extraction has a higher antioxidant activity than juice itself [21] and is a rich source of dietary fibre. Consumption of fruits rich in natural antioxidants has been shown to reduce the risk of chronic diseases such as cancer,

cardiovascular disease, brain and immune dysfunction [22]. In the maintain utilization processing waste which contain the major part of fruit nutrients/ antioxidants has been evolved as a major focus in the food industry.

Therefore, considering the above aspects, the present study was carried out to optimise the development of a functional mixed fruit beverage powder fortified with fibre rich fraction of carambola pomace.

2. MATERIALS AND METHODS

All the chemicals used were of analytical grade from taken to biochemistry lab and post-harvest technology analytical lab college of horticulture.

2.1. Materials

Carambola fruit: Ripe or unripe fruit that is not soft, mouldy or discoloured and free from bruises was purchased from the market of Azad pur mandi, Delhi, India and Ripe guava are purchase from local market of Banda.

2.2. Preparation of the carambola pomace powder

The selected fruit of carambola washing and cut in small pieces by the knife and pieces are crushed/grind by grinder. The juice was strained/ pressed through double level muslin cloth than collected juice and pomace. The collected pomace was dried 45⁰C at 4 to 5 hr by Hot Air Oven and collect sample in pp pouch.

2.3. Preparation of the Guava juice

The collected guava fruits are wash and cut in small pieces and then boiled, add 20% of water per Kg weight and the help of pulper to make pulp.

The making the guava juice to treated the pulp though pectinase enzyme. The weight of pulp one kg adds 0.22 mg enzyme and properly mixed. The mixed pulp is heated in 50⁰C at 1hr than dipped boiling water at 5 minutes for deactivate enzyme reaction. The pulp is putted double layer of muslin cloth and exquisite juice and pomace. The juice is collected for following treatment.

2.4. Preparation of Carambola Bagasse Fortified Mix Juice Powder

Carambola and guava and juice were blended in different proportions viz. 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50. The best juice mix was obtained by blending the fruit juice in the ratio of 50:50 (Guava: carambola) on the basis of overall acceptability. To the mixed juice 25% maltodextrin was added and the whole mix was blended using a DBK-Mini Mag stirrer. The final TSS of the feed mixtures were maintained to 10⁰B to maintain a constant feed flow rate. The fruit juice mixture was spray dried at inlet temperatures 180 °C and outlet temperature of

85°C in a laboratory scale spray drier (Model No. LSD- Mini Spray Dryer, JISL). The feed rate was maintained at 8ml/min. To the dried mixed juice powder, 5% of carambola bagasse powder was added and obtained product was packed in airtight glass jar at room temperature. The effect of storage on biochemical properties of carambola bagasse fortified mix juice powder was assessed for a period of 90 days.

2.5. Analysis of Product

TSS was determined with digital refractometer (0-80°B make Hanna). The parameters such as TSS, ascorbic acid and overall acceptability were analyzed by the methods suggested by [23]. Total phenolic content was analyzed by Folin-Ciocalteu method as described by [24]. Total antioxidant activity was estimated according to [25] using 6×10^{-5} mol/L solution of DPPH in methanol as a source of free radicals. The absorbance was recorded at 515 nm by UV-VS spectrophotometer using methanol as blank. Water activity of samples was measured using water activity meter (Model: LabSwift make Novasina). The samples were measured using moisture analyser (Model HE53 Make Mettler Toledo). The crude fiber content of samples was determined as per the method of [26] using automatic fiber analyzer (FibroTRON Make Tulin Ltd.). Total carotenoids sample was estimated through procedure suggested by [27].

3. RESULTS AND DISCUSSION

3.1. Effect of storage on biochemical properties

The results presented in **Table-1**. shows the effect of storage on biochemical properties of carambola bagasse fortified mix juice powder. The TSS of mixed juice powder decreased from a mean maximum value of 86.40°B to 87.60°B at 90 days. A gradual but non-significant increase in the TSS content was recorded with the advancement of storage duration up to 90 days. which might be due to hydrolysis of polysaccharides (starch) into monosaccharides (sugars). Similar results was found by [28] who observed the effect of maltodextrin levels on physico-chemical qualities of spray dried aonla (*Emblica officinalis* Gaertn.) juice powder. The results are in confirmation with the findings reported by [29,30,31,32,33,34]. Water activity of mix juice powder decreased from 0.365 to 0.315 at the end of storage. The ratio of water vapor pressure in a food system to pure water vapor pressure at the same temperature is known as water activity. The amount of free water in a food system that is involved in any metabolic activities is measured by water activity. Reduced water activity suggests a longer shelf life since there is less free water available for metabolic activities. It was also confirmed by the moisture content of juice powder during storage which showed similar trend. The moisture content is a fundamental property for spray-dried powders for determining its stability and

storage [35]. The similar results have been reported in spray dried Sohiong powder during the 12 days of storage period [36]. They also reported a non-linear increasing trend. This increase may be attributed to the sugars present in fruit and carrier agent, i.e. maltodextrin, which increased the water adsorption of powder [37]. The degree of increase or decrease in the moisture content of powder may also depend on the concentration of maltodextrin used in the feed. Similar results were also reported for spray dried yogurt and tamarind powders [38,39]. A gradual but non-significant decrease in crude fibre content was recorded during storage. The fibre content of juice powder decreased from 11.00 to 10.25% after 90 days.

Table 1. Effect of storage on biochemical properties of mix juice powder

Storage (Days)	TSS (°B)	Water Activity (a_w)	Moisture (%)	Crude fiber (%)
0	86.40	0.315	5.20	11.00
30	86.70	0.326	5.85	10.75
60	87.20	0.347	6.30	10.50
90	87.60	0.365	6.70	10.25
CD (0.05)	NS	0.015	0.064	NS
SE(m)	0.409	0.005	0.021	0.725
SE(d)	0.578	0.007	0.029	1.026
C.V.	0.940	2.836	0.682	13.652

3.2. Effect of storage on bioactive potential

The data pertaining to **Fig. 1 (a-d)** showed that the vitamin C content of carambola pomace fortify mix juice powder significantly decreased during storage at room temperatures. The maximum vitamin C content was recorded at 0 days (120.47mg/100g) which significantly decreased after 90 days (84.58mg/100g). This decreases the content of vitamin C may be attributed to the high reactivity of the enediol structure which increase at higher temperature and promotes degradative reactions as well as weakens the vitamin [40].

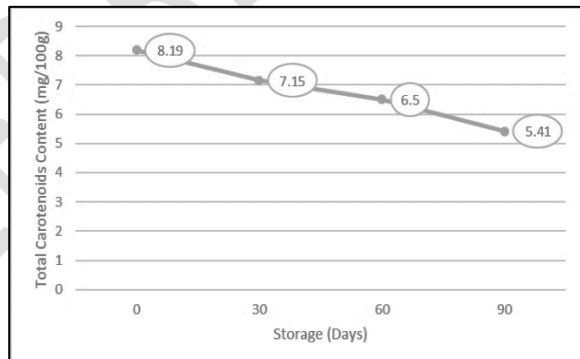
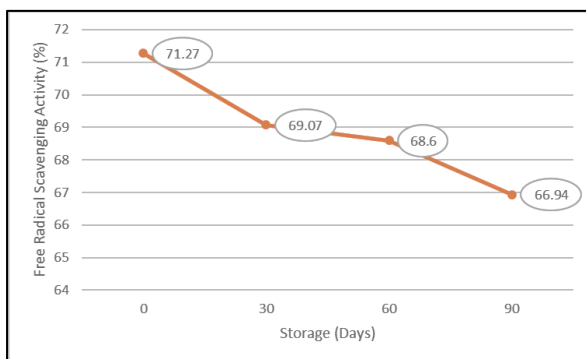
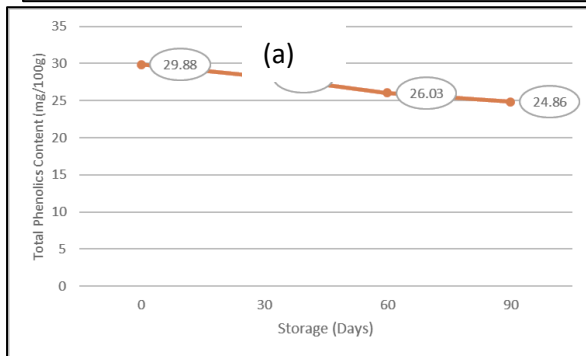
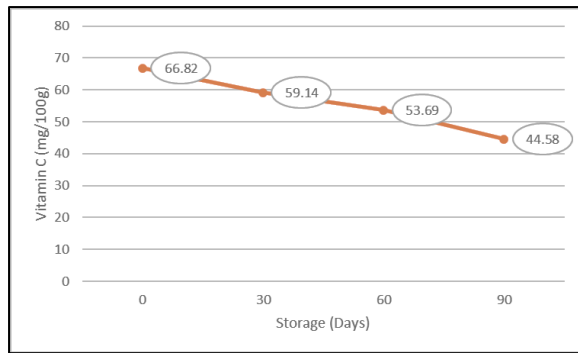


Fig 1: Effect of storage on Bioactive Potential of Mix Fruit Juice Powder Fortified with Carambola Bagasse a) vitamin C b) total phenolics content c) FRSA (Free radical Scavenging Activity) d) total carotenoids content

Free radical scavenging activity (FRSA) of carambola pomace fortify mix juice powder was not significantly influenced by the days of storage and showed a decrease during 0 to 90 days storage periods (Fig 1(c)). The highest value for FRSA was recorded as 71.27% at 0 days while the lowest as 66.94% at 90 days storage periods. Reduction in FRSA was probably due to high temperature storage which negatively affects the antioxidant compounds. The same has been confirmed by our results for TPC, vitamin C and total carotenoids content. Similar findings have been reported by [41] in spray dried bael fruit powder during storage. The observations showed that TPC value decreased during the storage at 90 days. The initial value decreased

from 29.88 and 24.86mg/100g during 90 days the storage periods. The decrease of the polyphenolic content at high temperatures may be due to increased oxidation of these bioactive components. The rates of these oxidation reactions increase as temperature increases. Smiler result was found by [42]. Effects of storage temperature on the total phenolic content of Cornelian Cherry (*Cornus mas* L.) fruits extracts. Total carotenoids value of the product decreased during the storage at 90 days from an initial value of 8.19 to 5.41 during 90 days the storage periods. The sensitivity of carotenoids to heat, light, and oxygen is very high. The combination of them may have provoked the oxidative process leading to convert carotenoid into aromatic compounds. Due to the presence of conjugated double bonds in the polyene chain, the total carotenoid would have been degraded by isomerization and oxidation under high temperature exposure [43]. Similar result was found by [44] during study on stability of bioactive compounds of microencapsulated mango and passion fruit mixed pulp.

3.3. Overall acceptability

The score recorded on 9-point hedonic scale for Overall acceptability of carambola pomace fortify mix juice powder was found to decrease during the storage at 90 days (Fig 2). It decreased from a mean initial value of 8.30 to 8.04 after 90 days under ambient storage conditions. Our result were in accordance to [45] who studied the effect of modified atmosphere packaging on sensory properties of spray-dried sea buckthorn fruit juice powder.

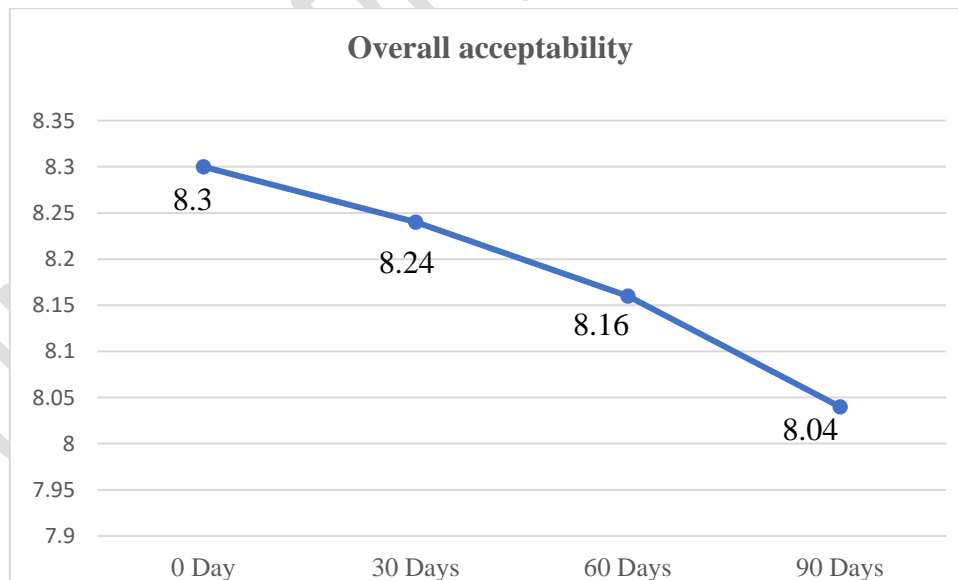


Fig 2. Effect of storage on overall acceptability of Mix Fruit Juice Powder Fortified with Carambola Bagasse

4. CONCLUSIONS

There was a significant effect of the storage duration on the quality of the Mix Fruit Juice Powder Fortified with Carambola Bagasse. The quality characteristics of juice powder namely, moisture content, a_w , and total soluble solids increased with the increase of the storage period whereas vitamin C, total phenolics, free radical scavenging activity and total carotenoids content of juice powder decreased with the increase of the storage period. Overall acceptability of the juice powder didn't show any significant change during the storage. Spray dried carambola mix juice powder thus can be made into a health promoting reconstituted drink and as well as found increase the shelf life of powder during the storage periods.

REFERENCES

1. Tze NL, Han CP, Yusof YA, Ling CN, Talib R A, Taip FS, Aziz M G. Physicochemical and nutritional properties of spray-dried pitaya fruit powder as natural colorant. *Food Science and Biotechnology*.2012;21(3), 675–682. <https://doi.org/10.1007/s10068-012-0088-z>
2. M. D. F. (n.d.). Fruit Powders Market Growth, Trends, Size, Share and Forecast to 2026. Market Data Forecast. Retrieved January 6, 2022, from <http://www.marketdataforecast.com>
3. Saifullah M, Yusof YA, Chin NL, Aziz MG. Physicochemical and flow properties of fruit powder and their effect on the dissolution of fast dissolving fruit powder tablets. *Powder Technology*. 2016;301, 396–404. <https://doi.org/10.1016/j.powtec.2016.06.035>
4. Molina R, Clemente E, Scapim MR da S, Vagula JM. (2014). Physical Evaluation and Hygroscopic Behavior of Dragon Fruit (*Hylocereus undatus*) Lyophilized Pulp Powder. *Drying Technology*. 2014;32(16), 2005–2011. <https://doi.org/10.1080/07373937.2014.929587>
5. Aguilera JoséM, del Valle JoséM, Karel M. Caking phenomena in amorphous food powders. *Trends in Food Science & Technology*.1995;6(5), 149–155. [https://doi.org/10.1016/S0924-2244\(00\)89023-8](https://doi.org/10.1016/S0924-2244(00)89023-8)
6. Khalloufi S, El-Maslouhi Y, Ratti C. Mathematical Model for Prediction of Glass Transition Temperature of Fruit Powders. *Journal of Food Science*. 2000;65(5), 842–848. <https://doi.org/10.1111/j.1365-2621.2000.tb13598.x>
7. Wang R, Hartel RW. Understanding stickiness in sugar-rich food systems: A review of mechanisms, analyses, and solutions of adhesion. *Comprehensive Reviews in Food*

- Science and Food Safety*. 2021;20(6), 5901–5937. <https://doi.org/10.1111/1541-4337.12833>
8. Simons SJR. Modelling of agglomerating systems: From spheres to fractals. *Powder Technology*. 1996;87(1), 29–41. [https://doi.org/10.1016/0032-5910\(95\)03078-6](https://doi.org/10.1016/0032-5910(95)03078-6)
 9. Li Y, Wang W, Guo L, Shao Z, Zhang T. Research progress on the interactions among particles and caking behavior of food powder. *Journal of the Chinese Cereals and Oils Association*. 2019;34(3), 126–132. <https://doi.org/10.3969/j.issn.1003-0174.2019.03.022>
 10. Bedford B, Liggans G, Williams L, Jackson L. Allergen Removal and Transfer with Wiping and Cleaning Methods Used in Retail and Food Service Establishments. *Journal of Food Protection*. 2020;83(7), 1248–1260. <https://doi.org/10.4315/JFP-20-025>
 11. Chitrakar B, Zhang M, Adhikari B. Dehydrated foods: Are they microbiologically safe? *Critical Reviews in Food Science and Nutrition*. 2019;59(17), 2734–2745. <https://doi.org/10.1080/10408398.2018.1466265>
 12. Moerman F, Mager K. Chapter 35—Cleaning and Disinfection in Dry Food Processing Facilities. In H. Lelieveld, J. Holah, & D. Gabrić (Eds.), *Handbook of Hygiene Control in the Food Industry* (Second Edition). Woodhead Publishing. 2016;521–554. <https://doi.org/10.1016/B978-0-08-100155-4.00035-2>
 13. Cai S, Phinney DM, Heldman DR, Snyder AB. (2020). All Treatment Parameters Affect Environmental Surface Sanitation Efficacy, but Their Relative Importance Depends on the Microbial Target. *Applied and Environmental Microbiology*. 2020;87(1), e01748-20. <https://doi.org/10.1128/AEM.01748-20>
 14. Maurya P. Formulation of star fruit (*Averrhoa carambola* L.) powder unified digestive food products and their quality evaluation. 2023.
 15. Luan F, Peng L, Lei Z, Jia X, Zou J, Yang Y, He X, Zeng N. Traditional uses, phytochemical constituents and pharmacological properties of *Averrhoa carambola* L.: A Review. *Front. Pharmacol*. 2021;12, 699899.
 16. Ramadan NS, Wessjohann LA, Mocan A, Vodnar DC, El-Sayed NH, El-Toumy SA, Mohamed, DA, Aziz ZA, Ehrlich A, Farag MA. Nutrient and sensory metabolites profiling of *Averrhoa Carambola* L. (Starfruit) in the Context of its origin and ripening stage by GC/MS and chemometric analysis. *Molecules* 22, 2020;25(10): 2423. doi: 10.3390/molecules25102423. PMID: 32455938; PMCID: PMC7287910
 17. Ghee, Lim Kean, et al. *Med. J. Malaysia*. 2019;74 (Aug) 701–719, 2121/01/2013

18. Frank SM, Webster J, McKenzie B, Geldsetzer P, Manne-Goehler J, Andall-Brereton G, Houehanou C, Houinato D, Gurung MS, Bicaba BW, McClure RW. Consumption of fruits and vegetables among individuals 15 years and older in 28 low-and middle-income countries. *The Journal of nutrition*. 2019; 149(7):1252-1259.
19. Cheng JT, Yang RS. Hypoglycemic effect of guava juice in mice and human subjects. *American Journal of Chinese Medicine*.1983;11.
20. Upadhyay R, Dass JFP, Chauhan AK, Yadav P, Singh M, Singh RB. Guava enriched functional foods: therapeutic potentials and technological challenges. *The role of functional food security in global health*. 2019;365-378.
21. Saikia S, Mahnot NK, Mahanta CL. Optimisation of phenolic extraction from *Averrhoa carambola* pomace by response surface methodology and its microencapsulation by spray and freeze drying. *Food chemistry*.2015;171, 144-152.
22. Avinash P, Swapneel K, Darshana P, Anita P. Comprehensive Review of an Important Medicinal Plant – *Averrhoa carambola* L. *Phcog Commn* 2. 2012;13-7.
23. Ranganna S. Handbook of Analysis and Quality Control for Fruits and vegetable Products. *Tata McGraw Hill Publishing Company Limited*, New Delhi.1986;150-280.
24. Chan EW, Lim YY, Wong LF, Lianto FS, Wong SK, Lim KK, Joe CE Lim TY. Antioxidant and tyrosinase inhibition properties of leaves and rhizomes of ginger species. *Food chemistry*. 2008;109(3):477-483.
25. Brand-Williams W, Cuvelier ME, Berset CLWT. Use of a Free Radical Method to Evaluate Antioxidant Activity. *LWT-Food Science and Technology*. 1995;28: 25-30. [http://dx.doi.org/10.1016/S0023-6438\(95\)80008-5](http://dx.doi.org/10.1016/S0023-6438(95)80008-5)
26. AOAC. Official Methods of Analysis. Association of Official Analytical Chemists.15th Edition. Washington D.C. 1990.
27. Akter MK, Motalab M, Zubair MA, Haque MZ, Saha BK, Mumtaz B. Isolation and Quantification of Lycopene and Determination of B-Carotene and Total Phenolic Contents from Tomato (*Lycopersicum Esculentum*) by using Various Methods. *Int J Food Sci Nutr Diet*. 2020;9(1), pp.442-447.
28. Poskar RL, Relekar PP, Pujari KH. Effect of maltodextrin levels on physico-chemical qualities of spray dried aonla (*Emblica officinalis* Gaertn.) juice powder. 2017;10(41) Print: ISSN 0974-8431, 8725-8728.
29. Park I, Kim JU, Shahbaz HM, Jung D, Jo M, Lee KS, Park J. High hydrostatic pressure treatment for manufacturing of garlic powder with improved microbial safety and

- antioxidant activity. *Int J Food Sci Technol.* 2018;54(2):325–334. <https://doi.org/10.1111/ijfs.13937>
30. Mariam Bi, Usha Devi C. Chemical and shelf-life analysis of dry garlic powder: a golden herb. *Int J Agric Food Sci Technol.*2016;7(1):1–6
 31. Li Y, Xu SY. Preparation of garlic powder with high allicin content. *Agric Sci China.* 2007;6(7):890–898. [https://doi.org/10.1016/s1671-2927\(07\)60127-8](https://doi.org/10.1016/s1671-2927(07)60127-8)
 32. Li Y, Xu SY, Sun DW. Preparation of garlic powder with high allicin content by using combined microwave–vacuum and vacuum drying as well as microencapsulation. *J Food Eng.* 2007;83(1):76–83. <https://doi.org/10.1016/j.jfoodeng.2007.02.057>
 33. Park S, Yoo S, Shim J, Chin K. Physicochemical properties, and antioxidant and antimicrobial effects of garlic and onion powder in fresh pork belly and loin during refrigerated storage. *J Food Sci.* 2008;73(8):C577–C584. <https://doi.org/10.1111/j.1750-3841.2008.00896.x>
 34. Kim YS, Oh SL, Nam KJ. A study on the development of new products from garlic (garlic powder). *Annual Report of Food Research Institute (Korea R.)*. 1980; p 55–74
 35. Arepally D, Goswami TK. Effect of inlet air temperature and gum Arabic concentration on encapsulation of probiotics by spray drying. *LWT-Food Science and Technology*, 2019;99, 583–593. <https://doi.org/10.1016/j.lwt.2018.10.022>.
 36. Vivek K, Mishra S, Pradhan RC. Characterization of spray dried probiotic Sohiong fruit powder with *Lactobacillus plantarum*. *Lwt - Food Science and Technology*. 2020;117-108699. <https://doi.org/10.1016/j.lwt.2019.108699>
 37. Molina R, Clemente E, Scapim M RdS, Vagula JM. Physical evaluation and hygroscopic behavior of dragon fruit (*hylocereus undatus*) lyophilized pulp powder. *Drying Technology*. 2014;32(16), 2005–2011. <https://doi.org/10.1080/07373937.2014.929587>
 38. Bhusari SN, Muzaffar K, Kumar P. Effect of carrier agents on physical and microstructural properties of spray dried tamarind pulp powder. *Powder Technology*. 2014;266, 354–364. <https://doi.org/10.1016/j.powtec.2014.06.038>.
 39. Koç B, Yilmazer MS, Balkır P, Ertekin FK. Moisture sorption isotherms and storage stability of spray-dried yogurt powder. *Drying Technology*. 2010;28(6),816–822. <https://doi.org/10.1080/07373937.2010.485083>
 40. Hernández-Sandoval GR, Cortés-Rodríguez M, Ciro-Velásquez HJ. Effect of storage conditions on quality of a functional powder of cape gooseberry obtained by spray

drying. *Revista UDCA Actualidad & Divulgación Científica*. 2014;17(1):139-149.
<https://doi.org/10.3389/fphar.2021.699899>.

41. Sornsomboonsuk S, Junyusen T, Chatchavanthatri N, Moolkaew P, Pamkhuntod N. Evaluation of physicochemical properties of spray dried bael fruit powder during storage. *International Journal of Food Engineering*. 2019;5(3):209-213.
42. Moldovan B, Popa A, David L. Effects of storage temperature on the total phenolic content of Cornelian Cherry (*Cornus mas* L.) fruits extracts. *Journal of applied botany and food quality*. 2016;89.
43. Loan NTC, Hoa NDH, Ha NVH. Effects of spray-drying conditions on antioxidant properties of mango powder. *Journal of Biotechnology*. 2016;14(1):427-438.
44. Rivas JC, Cabral LMC, Rocha-Leão MH. Stability of bioactive compounds of microencapsulated mango and passion fruit mixed pulp. *International Journal of Fruit Science*, 2020;20(sup2): S94-S110.
45. Selvamuthukumar M, Khanum F. Effect of modified atmosphere packaging on physicochemical, sensory and microbiological properties of spray-dried sea buckthorn fruit juice powder. *Journal of food quality*. 2014;37(3):149-156.