Abbreviated Key Title: Glob. J. Environ. Sci. Technol.
ISSN: 2384-5058 (Print) & Open Access
Vol. 12(2): Pp. 46-50, April, 2024.
DOI:10.54978
Global Journal of Environmental Science and Technology: ISSN-2360-7955, (Print) & Open Access
Volume-12 | Issue-4| April, 2024 | Research Paper

Design of a Berry Spray Dryer: A Case Of Tomatoes and Tomatillos

[1]Chiagorom V.C., [2]Anyaoha B.I., [3]Nzereogu I.K., [4]Osuchukwu L.C., [5]Meremikwu B.C., [6]Mbaoje E-M

Science and Engineering
Department of Biology, Faculty of Natural Sciences, University of Tirana, Bulevardi "Zogu i Parë", 25/1, 1001 Tirana, Albania
*Corresponding author e-mail: stela.ruci@fshn.edu.al

Corresponding author: Chiagorom,V.C., Accepted: 13/4/2024 Published: 23/4/2024

Abstract: Berry spray dryers are designed for the purpose of drying heat sensitive agricultural products such as tomatoes and tomatillos in order to increase their shelf life and make them available year round. Manufacturers use to produce fruit juice powder. The physiochemical properties of powders produced by spray drying depend on the variables of the process and/or operating parameters. Post-harvest loss in tomatoes and tomatillos is a major problem in the market supply chain of small farm holders.

Keywords: Spray dryers, tomatoes powders, tomatillo powders, shelf- life.
Published by GJEST

1.0 INTRODUCTION

Drying commonly describes the process of thermally removing moisture from a product to yield a solid particle and can be achieved via various methods, one of which is spray drying[1]. Spray drying is a one-step processing operation for turning liquid feed into dried powder by spraying the feed into a hot drying gas medium[2].This reduces the bulk weight and size, minimizes handling and also preserves the product by reducing its moisture content to a level unfavourable for bacterial degradation[3]. The concept is based on the high increase in surface area of contact between the material to be dried and the drying medium promoted by atomization.

Spray drying has been intimately associated with the dairy industry and dates back to the 1800 but industrial scale production did not start until 1850[4]. This technology, however, has been further developed to cover a large group and product capacities ranging from a few kg/hr to over 50t/hr[5].

The appearance, flow property, bulk density, solubility and storage stability of spray dried powders depend on the nature of the material and spray drying parameters.

The tomato (*Solanumlycopersicum L.*) is the world's largest produced and consumed vegetable crop. Tomatoes are well known as a health promoter having vitamins and disease fighting photochemical especially hycipene[6].

Tomatoes are low in saturated fat, cholesterol and sodium [1].

Post- harvest loss in Agricultural products is a major problem in the market supply chain of small farm holders in West Africa coupled with seasonal shortages. Tomatoes and tomatillos present a high moisture content making them more susceptible to decomposition by microorganism, chemical and enzymatic reactions rendering them extremely perishable and difficult to market or export as fresh produce. The general practice of preserving agricultural products such as tomatoes and tomatillos is either sun-dry, grind or refrigerate. While the former takes more time and the final product is bulky, the latter requires constant supply of electricity which is mostly unavailable hence the need for a different approach to increasing storage life, which reduces the weight, preserves its taste and curb losses associated with the transportation and storage of fresh products.

2.0 LITERATURE REVIEW

Drying is one of the oldest methods of preserving food, which involves the removal of moisture from the material, the oldest of which involves keeping products in

the sun for days as recorded in history (Rodriguez-Hernandez, et al; 2008). These days sun drying is obsolete as it either causes over- drying or under drying which results in not getting the desired goal. We apply drying to both food and non-food substances and materials

- **Food materials:** Food products are dried to prevent spoilage and enhance their storage. Grains, nuts and cereals are dried to specific moisture content lower than the original moisture content, retaining their viability and also preventing microbial attack8. Drying is not only to prevent browning during storage[9].
- **Nonfood materials**: Materials like wood, clothes, drugs and animal skin for example can be dried. The development of spray drying equipment and techniques evolved over a period of several decades from the 1870s through the early 1900s[10].

2.1 The Design Process Parameters: These are summarized to include the product recovery and produce end product recovery and produce the end product of a pre-refined specification[11].

2.2 Spray Drying Process: Fluid is first pumped to the atomization device where product particle breakdown occurs and air is drawn from the surroundings and passed through a filter and a heater to increase its temperature. Droplets produced by atomization and the hot drying air is introduced into the chamber where evaporation takes place, cooling the air in the process. Thermal efficiency, a parameter com15monly used for process atomization but in most cases, the process is guided more by product quality[12]. It is always advisable that the outlet temperature be kept low and the drying be achieved as quickly as possible[4].

2.2.1 Spray Drying Stages: There are four basic steps involved in spray drying[13].

Figure 1: Spray Drying Stages

- The atomization stage is designed to create optimum conditions for rapid evaporation as it converts feed into droplets[14].
- Droplet - Drying for contact stage: Is the central stage, the central element of a spray drier is the chamber; atomized liquid is brought into contact with hot drying air resulting in evaporation of the[15].

Moisture contained in the droplets. The manner of droplet-air contact influences the behaviour of the droplet during the drying phase and could be in the following ways[13] –

- Con-current : Air and particles move in the same direction
- Countercurrent: Air and particles move in opposite directions.
- Mixed Flow: Air and particle are subjected to co-current and counter flow

2.2.2 Spray Drying Parameters

Powder properties, such as moisture content, bulk density, particle size and hygroscopicity were affected by inlet temperature[16]. Moisture content is decreased with an increase in drying temperature, due to faster heat transfer between the product and drying gas[17]. An increase in inlet drying air temperature often results in the rapid formation of a dried layer at the surface and thus prevents more moisture from being evaporated. The effect of inlet temperature on tomato pulp investigated and was found that at constant feed flow rate, increase in inlet air temperature reduces the residual moisture content[18]. It was conclusion that a temperature range of 150^{O}C – 220^{O}C as ideal for the spray fry technique for food powder[19].

2.2.3 Drying Air Flow Rate: Moisture content in tomato and tomarillo powder increased with increase in drying – air flow rate[18] .

An increase of the drying air flow rate, decreased the residence time of the product in the drying chamber thereby leaving a product with a high moisture content. The higher content of water in the product leads to the powder stocking together resulting in a large bulk volume.

2.2.4 Feed Flow Rate: Higher flow rate of feed resulted in a shorter contact time between feed and drying gas as reported by[19]. They revealed that more well deposited and produced yield were got by increasing the flow rate. The high feed rate resulted in decreased heat and mass transfer and a lower process yield.

2.2.5 Atomizer Speed: According to result from correlation with earlier findings and it was stated that higher atomizer speed resulted in a smaller particle size and hence a quicker drying. This was as a result of an increased contact surface area between the drying gas and feed and a decreased in bulk density[19-21].

- **Components of a Spray Dryer:**

(i)Drying chamber.
(ii) Air circulation system – supply fan, heat gun and air distributor pipes, exhaust fan.
(iii) Atomization system – feed tank, feed pump, nozzle control valves
(iv) Product recovery system – cyclone separator filter bags.

2.4 Spray Drying Properties of Tomatoes and Tomatillos

Tomato/tomatillo pulp is very difficult to spray dry, as the powder tends to become soft and sticky while still warm and poses a caking problem due to its hygroscopic and thermoplastic behaviour. Various systems capable of producing a free flowing product are summarized to include[18]

- A con-current drying chamber having a jacketed well for air – cooling
- A Bars tower relies on the time-delayed fell of the product droplet and the very low temperature of the air flow.
- A chamber where particles are cooled with atmospheric air admitted near the bottom allowing transport of the powder to a collector having a low humidity atmosphere.
- A scraped surface drying chamber.

Spray drying parameters such as inlet temperature, air flow rate, feed flow rate, atomizer speed, type of carrier agent influence. The bulk density, particle size, moisture content, yield and hygroscopicity in spray dried materials[19].

The problem of tomato stickiness is mainly due to the low glass transition. Temperature (T_g) of the low molecular weight sugar present in them[17]. These problems were proffered solutions and recommended the addition of a carrier agent before atomization[22, 23.]

3.0 MATERIALS AND METHODS

3.1 The materials used for the machine are as follows –

- The chamber which is normally made of a stainless steal
- Cyclone made of stainless steel as well normally 5cm inlet duct, 10cm diameter, 30cm straight height, 3.25cm bottom opening.
- Blower of electrical component with a centrifugal far; 370W, 2.0a
- Spray gun of electrical component RDSG0202; 220V – 240V AV; 60W.
- Pipes of stainless steel 6.cm/25inch diameter
- Themstel of electrical component normally at a temp. of 400^{O}C
- Contactors of electrical (component used for connecting power to the machine.

3.2 Methods

Methods include the fabrication process and the finishing touches. The fabrication process involves:

- Marking out and cutting of sheet metal: according to the standard specification listed above.
- Chamber fabrication: using stainless steel materials according to design requirements.
- Welding process: which is the joining of two or more metals using electric form or AC or DC welding set.
- Electrical installation: All electrical parts ranging from blowers, spray gun, heater, thermostat were brought and installed on the various parts of the machine where they are required to be:
- Control panel fabrication: which consists of the power cord, the flip switches, the thermostat regulator and the indicator lights which is connected and indicates power supply, and the power supplied to each component.
- Finishing touches: The chamber and distribution pipes were cleaned which is grinding off of welded parts and filling up with metal filler to seal up and holes. The control panel is painted to limit rust.

4.0 RESULTS AND DISCUSSION

4.1 Result

Proper atomization of freshly grinded tomato and tomatillo fruits by the atomization device with a fine spray pattern with adjustable flow rates were achieved. There was a minimum air losses in the drying chamber. Adequate air circulation within the chamber was achieved using air draw from the surrounding by the blower. The atomization device has a knob for regulating the degree of atomization of spray materials.

Table 1: Results for drying tomato pulp at various temperature

Inlet temperature	Outlet temperature ^{O}C	Feed flow rate m^3/hr	Result
180	90	80	
170	90	80	
160	90	80	

Source: (Fisut, 2012)

Table 2: Inlet temperature for complete powder recovery of red and yellow tomarillo

Var	TSS	PH	Outlet temp. ^{O}C	Inlet temp ^{O}C
Red	9.8	3.9	90	164
Yellow	9.8	3.88	90	164

Source: (Fisut, 2012).

4.2 DISCUSSION

With 40gm addition of malt dextrin in 1litre of fresh pulp and with a feed flow rate or 80m/minute; an inlet air temperature of 160^{oC} for tomato and 164 for tomatillo with an outlet temperature of 90^{OC} were observed as the optimum conditions for the complete recovery of fruit powder.

CONCLUSION

It is concluded that spray drying is most effective in achieving fruit powders and a major relief to post harvest loss in fruit juice.

RECOMMENDATION

Clean tangy tomato and tomatillo juice are obtained by addition of five (5) parts of water with one (1) part of powder.

- The use of additives like Malto-dextrin can be used to enhance product output.
- Enhance sensory equipment can be used to control the drying parameters which are the backbone of spray drying.

REFERENCES

1. Charanjeet, K., George, B., Deepa, N. Singh, B. & Kapor, H.C. (2004). Antioxidant status of fresh and processed tomato. J. Food Sci. and Technology, 41(5): 479-486.

2. LATIFF,A. (2000). The biology of the genus elaeis. In advance in oil research, volume I. (Eds yusof basiron, jalani, B.S. and chan, KW). MPOB. 1938.

3. Obon, J.M, Castellar, M.R., Alacid, M. & Fernandezlopez, J.A. (2009). Production of a red-purple food colorant from Opuntiastricta fruits by spray drying and its application in food model system. Journal of Food Engineering. 90: 471-479.

4.Masters, K. (1994). Scale-up of spray dryers. Drying technol. 12:235-237.

5. Gabas, A.L., Telis, V.R.N., Sorbal, P.J.N. & Tehs: Romero, J. (2007). Effect of maltodextrin and Arobic gum in water vapour sorption thermodynamic properties of vacuum dried pineapple pulp powder. Journal of Food Engineering. 82:246 – 253.

6. Dolinsky, A., Maletskata, Y. & Snezhkin Y. (2000). Fruit and vegetable powders production technology on the bases of spray and convective drying methods. Drying technology 18: 747 – 78.

7. Rudriguaz – Herbardez, G.R. Gonzalez – Garcia, R., Grajales – Lagumes, A. & Rinz – Cabrera, M.A. (2005). Spray-drying of cactus pear juice (Opuntiastreptacanta): Effect on the physiochemical properties of powder and reconstituted product. Drying Technology 23: 95-973.

8. Shrestha,, B.R. Howes, To & Bhandari, B.R. (2007). Class transition behaviour of spray dried orange juice powder easier by differential scanning calorimeter (DSC) and themal mechanical compression test (TMCT). International Journal of Food Properties. 10:661-673.

9. Reineccius, G.A. (2001). Multiple – core encapsulation – the spray drying of food ingredients. In P Vilstrup (Ed). Microencapsulating of food ingredients. Leather heat publishing survey, UK.

10. Righetto, A.M. & Netto, F.M. (2005) Effect of encanpsulating materials on water sorption, glass transition and stability of juice from immature accrola. International Journal of Food Properties 8:337-346.

11. Truong, V., Bhandari, B.T & Howes, T. (2000). Moisture and glass optimization of Co-current spray drying process of sugar rich foods. Transition temperature problem during drying. Journal of Food Engineering. 71: 5 – 65.

12. Oguoma ,O.N,C. CO nwuzuruigbo & Nnamdim (1993) design of Palm kernel/shell separation for developing countries. NIG .J. Tech. Edu, 1-2

13. Sagar, V.R. & Suresh Kumar, P. (2010). Recent advance in drying and dehydration of fruits and vegetable: a review. Journal of food Science and Technology 47:15-26.

14. BETE Manual (2005).

15. Toneli, J. Park, K.J., Murr, F & Negreiors, A. (2006). Spray drying optimization to obtain inulim powder. In: proceedings of the 1th international drying symposium (IDS 2006). Budapest, Hungary.

16. Anandharamakrishnan, C.J., Gimbum, A.G.F., Stapley & Reilly, C.D. (2008). A study of particle histories during spray drying using computational fluid dynamics. Simulations In: 16th International drying symposium IDS 2008, 9 -12th November 2008, Hyderabad, Dubai, Vol. A, pp. 265-272.

17.Tonon, V.R.; Brabet, C. & Hubinger, N. (2011). Spray drying of acai juice: Effect of inlet temperature and type of carrier agent. Journal of Food Processing and Preservation. 5: 691-700.

18.Goula, A.M. & Adamopoulos, K.G., (2008). Effect of maltodextrin addition during spray drying of tomato pulp in dehumidified air. II. Powder properties. Drying technology 26: 726737.

19.Chegini, R.G., & Ehobadian, B. (2005). Effect of spray drying conditions on physical properties of orange juice powder. Drying technology, 23: 657-668.

20.Roos, Y. & Kernel, N. (1991): Water and Molecular weight effect on glass transitions and amorphous carbohydrates and carbohydrate solution. Journal of Food Science 56: 1676 – 1681.

21. Phisut, N. (2012). Spray drying technique of food juice powder: some factors influencing the properties of product. International Food Research Journal. 19(4): 1297-1306 (2012)

22. Oxford Advanced Learner's online Dictionary, 2023.

23. Webster online Dictionary, 2023technology 26: 726737.