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Production and properties of spray dried carrot powder

Priti Jain and Mohan Singh

Abstract
Using response surface methodology, carrot juice with added malt dextrin was spray dried with an air inlet temperature of 150, 160 and 170 °C and feed flow rate *viz*., 80, 120 and 160 ml/h. The air pressure was 2 bar and outlet temperature of 75 °C. Fresh carrot juice was concentrated by addition of 8% encapsulating agent (maltodextrin), and then dried using a lab spray-dryer. The physical properties studied were: moisture content, solubility, hygroscopicity, bulk density, color and product recovery. The results showed that the quadratic model used reporting the relation of the independent variables was significant for all the dependent variables.

Keywords: Carrot powder, spray drying, solubility, hygroscopicity, product recovery

Introduction
Carrot (*Daucus carota*) is major vegetable crop of India. Haryana, Andhra Pradesh, Karnataka, Punjab and Uttar Pradesh are major carrot growing states with average yield of 120qtl/acre. It is crunchy, tasty, and highly nutritious. Carrots are a great source of many plant compounds, especially carotenoids, such as beta carotene, lutein fiber, vitamin K1, potassium, and antioxidants. Carrot powder is a nutritional, convenient option as an added ingredient. It provide us with a number of important health benefits include promoting good eye health, supporting heart and cardiovascular function, maintaining appropriate blood glucose levels, preventing cancer, and promoting skin health and overall wellness. It can be used in a number of products, including smoothies, carrot cake, muffins, stews, sweet dishes, and gravies.

Spray drying is a method of producing a dry powder from a liquid or slurry by rapidly drying with a hot gas. This is the preferred method of drying of many thermally-sensitive materials such as foods and pharmaceuticals. (Mujumdar, 2007) [11].

The spray drying of concentrated syrup and juice rich with low molecular weight sugars (such as fructose, glucose and sucrose), and organic acids (citric, tartaric and malic) lead to the low glass transition temperature and adhesion of these products makes it very difficult to dry in normal conditions (Cano-Chauca *et al.* 2005) [4]. The most common solution to reduce the adhesion of these products is the use of high molecular weight drying aid compounds such as Gum Arabic, and a variety of starch and its derivatives such as maltodextrin (Quek et al. 2007; Goula and Adamopoulos 2012) [12, 8].

The major reason for production of carrot powder is to prolong shelf life and to facilitate storage and handling. The shelf life of carrot powder is generally established to warrant microbiological safety and to keep acceptable sensory characteristics such as color and flavor. The objectives of the present study were to optimize the process parameters and to analyze the physical properties of spray dried carrot powder.

Materials and Methods
Preparation of Fresh Carrot Juice
Fresh carrots were purchased from a local market. They were washed in clean water to remove dirt. The juice was extracted by using a juicer. Quantity of extracted juice from one kg of carrot was 510 ml. The juice was sieved through a sieve with 200 meshes to remove pulp and other solids and then transferred into glass bottles.

Spray drying procedure
A lab spray dryer was used in the spray-drying process. Spray drying was carried out at a various inlet air temperature *viz*., 150, 160 and 170 °C and feed flow rate *viz*., 80, 120

and 160 ml/h with constant outlet air temperature of 75 °C and constant air pressure of 2 bar. The total juice solids were adjusted with constant amount 8% of encapsulating agents (maltodextrin).

The feed solutions were kept under magnetic agitator at room temperature and fed into the drying chamber through a pump. The dryer was washed with water at the desired setting for 10 min before and after the spray-drying process. Then, spray-dried encapsulated powder was collected, weighed and sealed in plastic container.

Spray Drying of Carrot Juice

Experimental Design

In this study, response surface methodology was used with two factors three level to investigate the individual and interactive effects of drying process variables such as inlet air temperature and feed flow rate on quality attributes moisture content, solubility, hygroscopicity bulk density, colour, and product recovery.

Determination of physical parameters of Carrot powder

Moisture content

Moisture content of the sample was determined by using a calibrated Digital Moisture Analyzer (OHAUS, MB45 Moisture Analyzer, New Jersey, UAS) at 100°C. A sample of one g in triplicate was exposed to the heated infra-red coils of the moisture analyzer and the analysis was completed in an automatic mode within 10 minutes.

Solubility

Solubility was determined using a modified version of the method of Al-Kahtani and Bakri (1990) [2]. A small sample of dry powders of 0.6 g was added to 400 ml of water at 70 °C in a 50 ml beaker. The mixture was stirred using a magnetic stirrer at 7 rpm. Solubility was measured as the time taken to dissolve the dry powders completely.

Hygrscopicity

About 1 g of beetroot powder was spread evenly on Petri dishes (9 cm diameter) to allow for a high surface area between humid air and powder. Samples of each powder were placed in respective seprate dishes in disiccator at 23 °C and 76% relative humidity using HNO_3 solution. Ten minutes interval was selected to get the kinetics of moisture sorption (Al- Kahtani and Hassan, 1990).

Bulk density

Bulk density (g/mL) was determined by gently adding 2 g of powder into an empty 10 mL graduated cylinder. The ratio mass and the volume of powder occupied in the cylinder determine the bulk density value (Goula and Adamopoulos, 2004) [9].

Colour

The color of different samples was measured using a colorimeter (Hunter lab).The results were expressed in b value, which determined the degree of yellowness characteristics of the various carrot colorant samples.

Product recovery

The product recovery was calculated as the mass ratio of the dried powder collected at the end of spray drying process to the initial solid content in the feed. The product recovery was calculated with following equation by Ahmad (2019) [1].

$$Product\ Recovery, \% = \frac{The\ weight\ of\ obtained\ spray\ dried\ powder}{The\ total\ solid\ weight\ in\ initial\ feed} X\ 100$$

Results and Discussion

In the present investigation efforts were made to optimize the process parameters for carrot powder. Effects of process parameters (inlet air temperature and feed flow rate) on physical properties of carrot powder at constant outlet air temperature of 75 °C and constant air pressure of 2 bar were studied.

Effect of spray drying parameters on physical properties of carrot powder

The effect of process parameters on the physical properties of the spray dried carrot powder have been shown in following point:

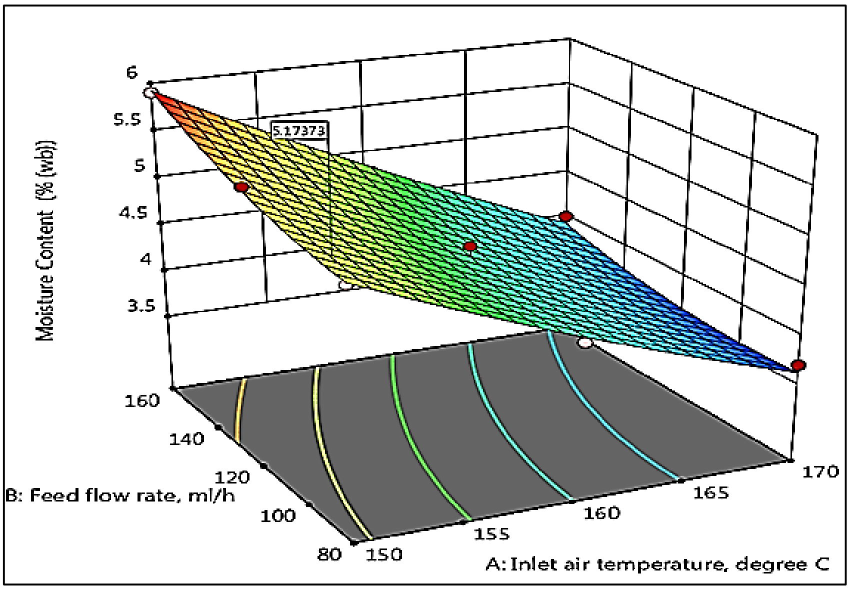

Fig 1: Effect of inlet air temperature and feed flow rate on the moisture content of carrot powder

Moisture Content

Figure 1 shows the effect of different inlet air temperature and feed flow rate on the moisture content of carrot powder. The moisture content of spray dried carrot powder was in the range of 3.7–5.9%. The moisture content of the carrot powder decreased with the increase in the inlet air temperature from 150 to 170ºC due to faster diffusion. From the analysis, inlet air temperature and feed flow rate are the dominating variables and are most significant. An increased feed rate resulted in higher moisture content due to the fact that during higher feed flow rate, heat transfer between the feed droplets and the drying air became less efficient causing lower water evaporation, thus producing higher moisture content in spray drying process.

Solubility

Solubility is the ability of powder to fully dissolve in aqueous solution to form a suspension in water. This parameter is a fundamental criterion to assess the powder behaviour in an aqueous solution as it is an indicator of reconstitution quality of powders (Bicudo *et al.* 2015). The solubility of carrot powder increased with an increase in inlet air temperature from150 to 170°C (Figure 2), because moisture content of the encapsulated powder decreases with an increment in inlet air temperature which results in an increment in the solubility of obtained carrot powder. Increase in drying air temperature generally produces the particles of larger size requiring lesser time to dissolve i.e. encapsulated powders with lower moisture content are more soluble. An increased feed flow rate from 80 to 160 ml/h resulted in decreased solubility due to Whereas an increase in feed flow rate from 80 to 160 ml/h decreased solubility due to higher residual moisture content of the encapsulated powder resulting in lower solubility of encapsulated powder. The range for solubility of the spray dried carrot powder varied from 72.5 to 79.6%.

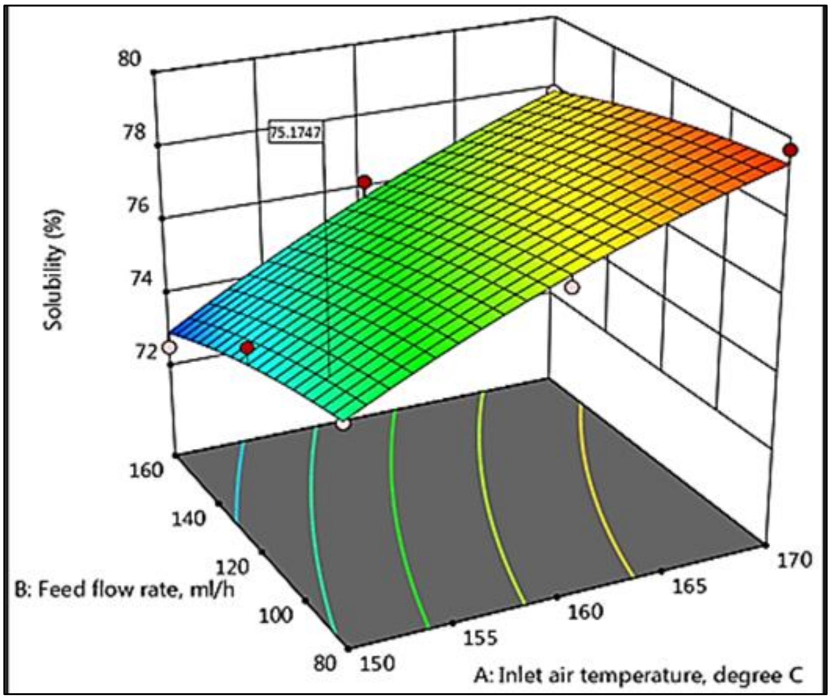

Fig 2: Effect of inlet air temperature and feed flow rate on solubility of carrot powder

Hygroscopicity

The highest hygroscopicity 0.23% (Figure 3), indicating its strong capacity to attract water molecules when in contact with the surrounding air. Usually, the moisture content of the samples has a direct relationship with the hygroscopicity, as shown by Tonon *et al.* (2008) [15] and Caparino *et al.*, (2012) [6] where the low moisture of the spray-dried product has a greater capacity to absorb water from the surrounding air and hence is more hygroscopic. Hygroscopicity of the carrot powder increased with the increase in the inlet air temperature and decreased with increase in feed flow rate. The range for hygroscopicity of the spray dried carrot powder varied from 0.19 to 0.23 g/g.

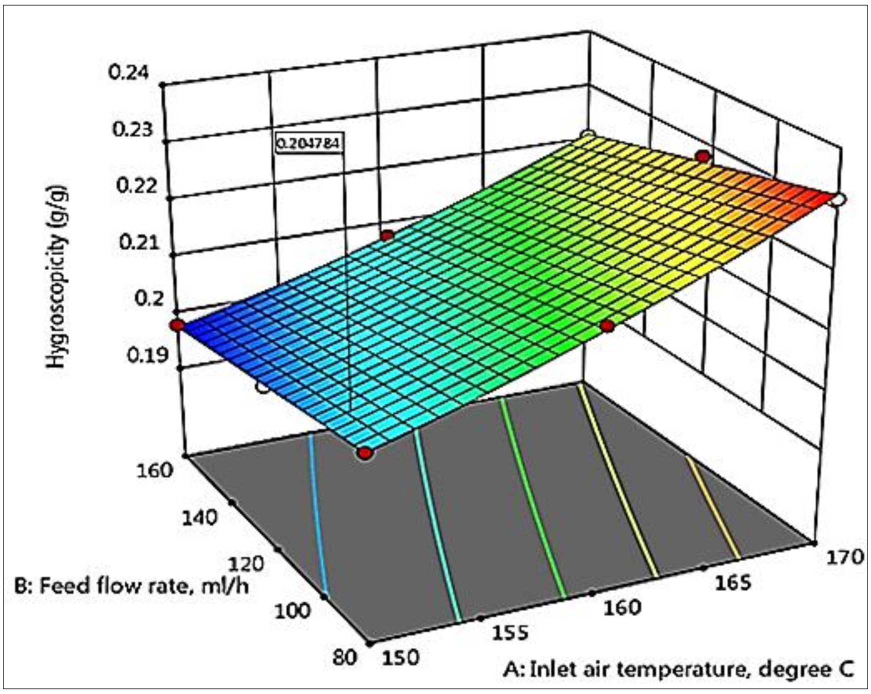

Fig 3: Effect of inlet air temperature and feed flow rate on hygroscopicity of carrot powder

Bulk Density

The bulk density of the carrot powder decreases with an increase in the inlet air temperature (Figure 4). The bulk density of the carrot powder decreased with the increase in the inlet air temperature from150 to 170°C and increased with increase in feed flow rate from 120 to 150 ml/h due to the lower moisture content of the powders and increase in void spaces. The range for bulk density of the spray dried carrot powder varied from 0.52 to 0.69 g/ml.

It is desirable for a powder to have a high bulk density as it will require less volume when packaged In addition, a powder with a high bulk density usually has less empty space between particles when it is packed and, therefore, less air occupies these spaces, which can help to prevent oxidation and increase the stability of the powder.

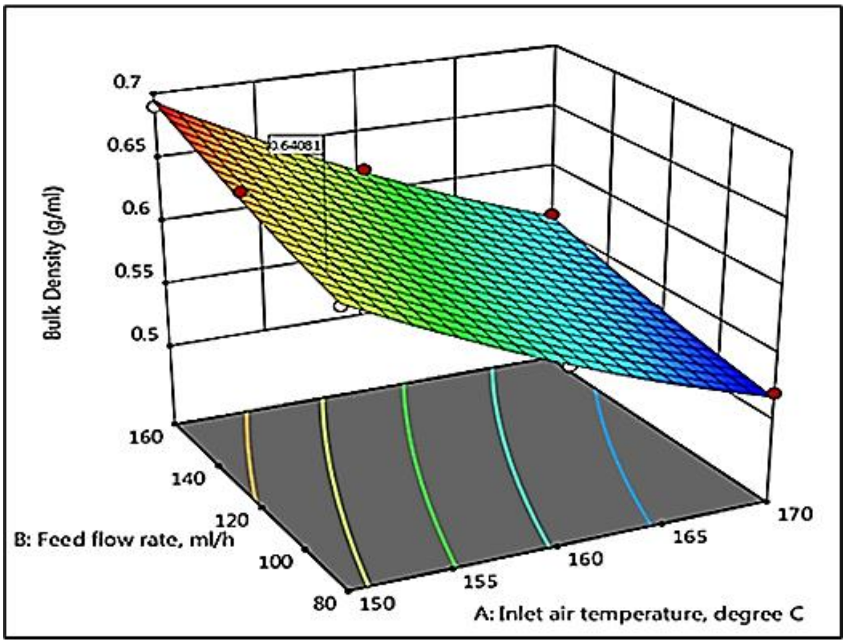

Fig 4: Effect of inlet air temperature and feed flow rate on bulk density of carrot powder

Colour 'a' value

Color characteristic is an important indicator of quality; it reflects sensory attractiveness and the quality of the powders produced in the spray drying process. The figure 5 indicated that a decrease in the inlet air temperature decreased the color value of the carrot juice powder; The colour 'a' value of the carrot powder decreased with the increase in the inlet air temperature from150 to 170ºC due to be the degradation of colour at higher temperature and increased with increase in feed flow rate from 120 to 150 ml/h due to larger amount of residual moisture in carrot powder. The range for colour 'a' value of the spray dried carrot powder varied from 6.9 to 8.6.

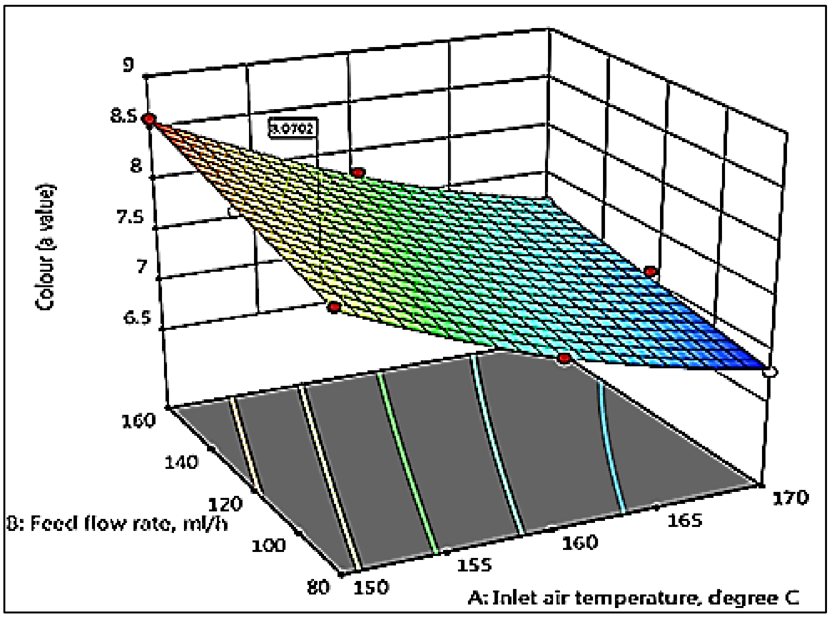

Fig 5: Effect of inlet air temperature and feed flow rate on colour 'a' value of carrot powder

Product recovery

The powder recovery of spray dried carrot powder with 8% maltodextrin as carrier was determined using different inlet temperatures during spray drying (Figure 6). Spray drying of carrot powder at an inlet temperature of 160°C and feed flow rate of 120 ml/h resulted in the highest yield in contrast to other drying temperatures. The increase in yield when spray drying in our study is in agreement with yield of spray dried banana powder (Wong *et al.* 2017) [16], black mulberry powder (Fazaeli *et al.* 2012) [7] and pomegranate powder (Jafari *et al.* 2017) [10]. The powder recovery of carrot powder decreased slightly for higher inlet temperatures at 170°C. This could be due to the stickiness of powder that can occur when the spray drying inlet temperature is higher than the glass transition of the sugars in the carrot powder (Wong *et al.* 2017) [16].

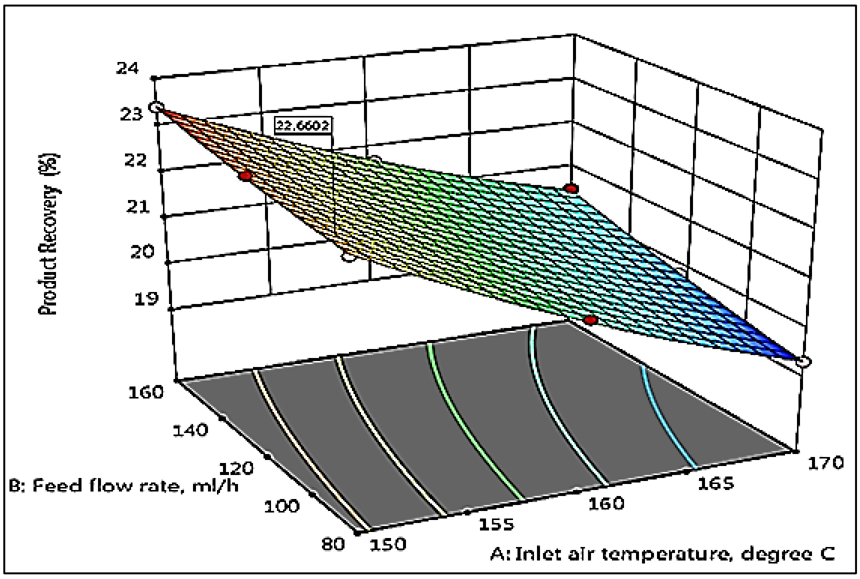

Fig 6: Effect of inlet air temperature and feed flow rate on product recovery of carrot powder

Conclusion

The inlet air temperatures and feed flow rate affected the quality of dried carrot powder. Maltodextrin as an encapsulating agent increased the product yield. Higher inlet air temperature showed an increase in solubility, hygroscopicity, and a decrease in moisture content, colour value, bulk density and product recovery. Higher feed flow rate showed an increase in moisture content, colour value, bulk density, product recovery and a decrease in solubility and hygroscopicity. The best quality carrot powder was achieved at inlet air temperature of 160 °C and feed flow rate of 120 ml/h.

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Conflict of interest Statement: The authors declare that there is no conflict of interest.

References
1. Ahmad Al Mubarak, Nazimah Hamid, Rothman Kam, Henry Chan. The Effects of Spray Drying Conditions on the Physical and Bioactive Properties of New Zealand Tamarillo (*Solanum betaceum*) Powder. Acta Scientific Nutritional Health 2019;3(12):121-131.
2. Al-Kahtani HA, Hassan BH. Spray drying of roselle (*Hibiscus sabdariffa* L.) extract. Journal of Food Science 1990;55:1073-1076.
3. Bosma TL, Dole JM, Maness NO. Optimizing marigold (*Tagetes erecta* L.) petal and pigment yield. Crop Sci 2003;43(6):2118-2124
4. Cano-Chauca M, Stringheta PC, Ramos AM, Cal-Vidal J. Effect of the carriers on the microstructure of mango powder obtained by spray drying and its functional characterization. Innov Food Sci Emerg Technol 2005;6:420-428.
5. Cantrill R. Lutein from *Tagetes erecta*. Chemical and Technical Assessment (CTA). 63rd meeeting of JECFA, on Food Additives, FAO 2004.
6. Caparino OA, Tang J, Nindo CI, Sablani SS, Powers JR, Fellman JK, *et al*. Effect of drying methods on the physical properties and microstructures of mango (Philippine ‘‘Carabao’’ var.) powder. Journal of Food Engineering 2012;111(1):135-148.
7. Fazaeli M, *et al*. Effect of spray drying conditions and feed composition on the physical properties of black mulberry juice powder. Food and Bioproducts Processing 2012;90(4):667-675.
8. Goula AM, Adamopoulos KG. A method for pomegranate seed application in food industries: seed oil encapsulation. Food Bioprod Process 2012;90:639-652.
9. Goula AM, Adamopoulos KG. Spray drying of tomato pulp: effect of feed concentration. Drying Technology 2004;22:2309-2330.
10. Jafari SM, *et al*. Influence of spray drying on water solubility index, apparent density, and anthocyanin content of pomegranate juice powder”. Powder Technology 2017;311:59-65.
11. Mujumdar AS. Handbook of industrial drying. CRC Press 2007, p. 710. ISBN 57444-668-1.
12. Quek SY, Chok NK, Swedlund P. The physicochemical properties of spray-dried watermelon powders. Chem Eng Process Process Intens if 2007;46:386-392.
13. Setshogo MP. *Tagetes erecta* L. Record from PROTA4U. Jansen, P.C.M. & Cardon, D. (Editors). Plant Resources of Tropical Africa, Wageningen 2005.
14. Sowbhagya HB, Sampathu S, Krishnamurthy N. Natural Colorant from Marigold-Chemistry and Technology Food Reviews International 2006;20(1):33-50.
15. Tonon RV, Brabet C, Hubinger MD. Influence of process conditions on the physicochemical properties of ac¸ai (*Euterpe oleraceae* Mart.) powder produced by spray drying. Journal of Food Engineering 2008;88(3):411:418.
16. Wong CW, *et al*. Effect of enzymatic processing, inlet temperature, and maltodextrin concentration on the rheological and physicochemical properties of spray-dried banana (*Musa acuminata*) powder. Journal of Food Processing and Preservation 2017.