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Temperature and feed flow rate effects properties of spray dried papaya leaf powder

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Abstract
The present study aims to determine the effects of inlet air temperature and feed rate on the main powder properties during spray drying of papaya leaf powder. Parameters analyzed were yield, moisture, color and flavonoid content. Design expert with three inlet air temperatures (130, 140 and 150°C) and three feed rate levels (350, 475 and 600 mL/h) were investigated. There was significant effect of inlet air temperature and feed rate on yield, color and moisture content while no remarkable changes in flavonoid content was observed. Increase in feed rate substantially reduced production of papaya leaf powder. Furthermore, the amount powder was higher with elevated feed rate but lesser with increasing inlet temperature.

Keywords: Papaya leaf powder, spray drying, total flavonoid content, physicochemical properties.

Introduction
Papaya is known as common man's fruit due to its reasonable price and high nutritive value. Papaya is rich in iron and calcium; a good source of vitamins A, B and an excellent source of vitamin C (ascorbic acid). Fresh, green papaya leaf is an antiseptic, while the brown, dried papaya leaf is the best as a tonic and blood purifier and carica papaya leaves extracts used to treat dengue fever in patients (Ahmad *et al.,* 2011) [1]. Recent reports have claimed possible beneficial effects of papaya leaf juice in treating patients with dengue viral infections (Yunita *et al.,* 2012) [14]. In some parts of Asia, the young leaves of the papaya are steamed and eaten like spinach. The extracts of both the leaves and fruit are known to contain several proteins and alkaloids with important pharmaceutical, medical and industrial applications. Interestingly, papaya fruit juice and leaf extract have demonstrated anti-cancer properties. In a recent study it is found that, the powder from papaya leaves is responsible for the release and production of thrombocytes/platelets (Patil *et al.,* 2013) [13].
Spray drying technique is an important and routine practice in food industries, used for continuous transformation of feed from a liquid state into dried particulate form by spraying feed into a hot drying medium. The main advantages of spray-drying as compared to other drying methods are minimum increase of material temperature with high rate of drying. There are several factors in spray drying like inlet air temperature and feed rate which affects the properties of powder (Chegini *et al.,* 2007, Bayram *et al.,* 2008 & Szente *et al.,* 1986) [5, 4, 12]. In order to design a good spray drying control system, the selection of operating parameters is important to ensure the desired quality of final products. It was found that the product with lowest moisture and high quality were obtained when outlet air temperature was in the range of 100-110°C (Tan *et al.,* 2010) [13].
The spray dried powder of papaya leaf powder has good reconstitutional characteristics, low water activity, suitable for transportation and improved shelf-life. It can be easily added to other foods. Thus spray drying is the best alternative to obtain colorants and natural flavouring (Langrish *et al.,* 2009) [9]. Although spray drying of food materials are affected by several parameters but inlet air temperature and feed rate are very important parameters. Therefore, this study was conducted to examine the effect of the spray drying temperatures and feed flow rate on the papaya leaf powder.

Materials and Methods
Preparation of papaya leaf juice
Green papaya leaves of same maturity level were collected from local field, leaves were washed and sliced. The sliced leaves were again washed with mineral water.

From papaya leaf slices, juice was extracted by using INTEX mixer grinder. For each experimental run, the papaya leaves (1 kg) was blended in distilled water (250 mL), in the ratio of 1-0.25. The juice was separated from papaya leaf waste through filtering.

Preparation of spray dried papaya leaf powder

The resulting papaya leaf juice was twice filtered using a muslin cloth to avoid blocking of the atomizer of the spray dryer. The carrier agent maltodextrin of 8%, 10% and 12% w/v was added to the papaya leaf juice to increase concentration and to reduce hygroscopi city of the dried powder. Initially papaya leaf juice has 5 ºBrix after addition of maltodextrin concentrations 8%, 10% and 12% w/v, the °Brix was increased to 13%, 15% and 17% °B, respectively. Then the concentrated papaya leaf juice was fed in to the drying chamber with feed flow rates of 350 mL/h, 475 mL/h, 600 mL/h and inlet air temperatures were maintained at130 ºC, 140 ºC and 150 ºC temperatures. Obtained powder was stored in aluminium laminated polyethylene covers under ambient conditions.

Yield

The yield of spray dried papaya leaf powder was measured by weighing.

Moisture Content

The moisture content was determined in accordance to moisture measurement method of AOAC (2000) [2].

Total flavonoid content

The method used for determination of total flavonoid content was adapted from Kamtekar *et al.* (2014) [8]. Quarcetin solution (100 mg/ml) was used to construct the standard curve. Total flavonoid content of the spray-dried papaya leaf powder was spectrophotometrically determined at 510 nm and the data of total flavonoids of papaya leaf powders were expressed as mg of quercetin equivalents/100 g of dry mass.

Experimental Design

The Box-Behnken design has better prediction precision in the center of the factor space (Design-Expert 10.0.6.). The 3-factor-3-level Box-Behnken design (Montrogomery, 2008; Box and Behnken, 1960) with eight replicates at the center point was used for spray drying of papaya leaf juice, considering three independent variables: inlet air temperature (130 ºC, 140 ºC and 150 ºC), feed flow rate (350 mL/h, 475 mL/h and 600 mL/h) and maltodextrin concentration (8 %, 10 % and 12 %) to develop predictive models for different responses. A total of 17 experiments were conducted including the central point.

Results and Discussion

Figure 1 shows the yield (g) of papaya leaf powder from 300 mL papaya leaf juice with different combinations of air flow temperature and feed rate. There was a significant difference in the yield for both inlet air temperature and feed rate. The yield was decreased with increasing feed rate from 350 mL/h to 600 mL/h at each air flow temperature. The highest yield was found at 130°C inlet air temperature and feed rate of 350 mL/h where as the 130°C and 600 mL/h exhibited lowest yield. At inlet air temperature of both 130 and 140°C,increase in feed rate from 350 mL/h to 475 mL/h and 600 mL/h leads to a significant decrease in yield of papaya leaf powder. However, at 600 mL/h and 475 mL/h no remarkable changes were observed. At 150 °C, yield was lower at feed rate 350 mL/h, 475 mL/h and 600 mL/h. A higher feed rate caused an increase in the drying load as sample is sucked into the drying chamber and sprayed at a faster rate. Consequently, higher amount of extract was not dried due to accumulation in drying chamber resulting in decreased yield.
According to Filkova and Mujumdar, temperature is not much effective at lower feed rate because of low drying rate. Hence, the drying capacity is sufficient to dry all the particles. However, at higher feed rate like 600 mL/h, the drying load increased and a low inlet air temperature produces low drying capacity, resulting in lesser yields.

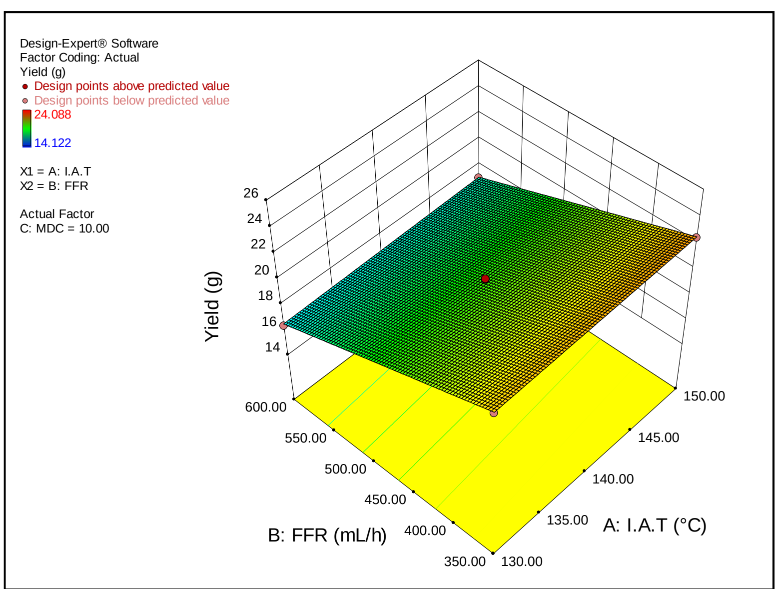

Fig 1: Response surface plot for yield (g) of spray dried papaya leaf powder as affected by feed flow rates (mL/h) and inlet air temperatures (ºC)

Moisture content

Figure 2 shows the effect of inlet air temperature and feed rate on the moisture content in papaya leaf powder produced from 300 mL papaya leaf juice. At inlet air temperature of 130°C, there was marginal effect on moisture content at different feed rates (350, 475 and 600 ml/h). Similar result was observed at 140°C. However, at 150°C, there was large increase in the moisture content of samples produced at 600 mL/h feed rate.

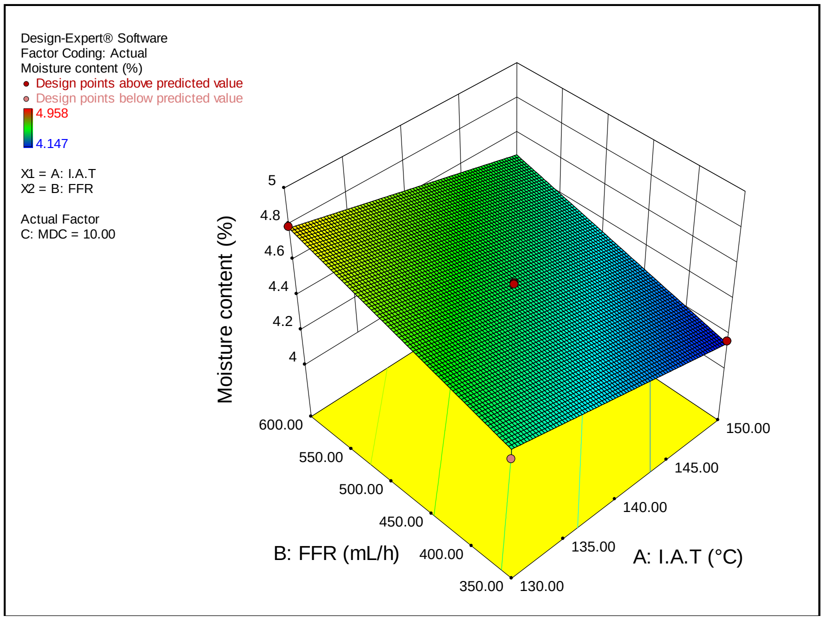

Fig 2: Response surface plot for moisture content (%) of spray dried papaya leaf powder as affected by feed flow rates (mL/h) and inlet air temperatures (ºC)

There was no evident change in moisture content at 130°C when feed rate increased from 350 to 600 mL/h. This is because of low drying capacity. However, at 150°C drying capacity was high which resulted lower moisture content in papaya leaf powder. Kieviet *et al.* (1994) reported that increased feed rate resulted in higher moisture content due to the increase load in drying chamber. At a feed rate of 350 mL/h, there was trivial change in moisture content when temperature increased from 130 to 150°C. However, significant decrease in moisture content was occurred when the temperature increased from 130 to 150°C. Similarly, at feed rates of 475 and 600 mL/h, increasing the temperature from 130°C to 150°C resulted in a large reduction in moisture content. Higher inlet air temperature produced higher drying capacity. Exposure of particles with hotter air lead to dried particles thus, lowers moisture. Jumah *et al.* (2000) [7] reported that higher inlet air temperature caused a decrease in moisture content of sample.

Total flavonoid content

The total flavonoid content of spray dried papaya leaf powders were obtained in the range of 51.86 to 65.04 mg/g of powder. As increase in the inlet air temperatures from 130 ºC to 150 ºC increased the loss of total flavonoid content of spray dried papaya leaf powder. Silva *et al.* (2011) [11] also reported that decrease in total flavonoid content and total phenolic content level during spray drying process. At higher feed flow rates, shorter contact between the feed and drying air making the heat transfer less efficient and thus total flavonoid content will be more. Similar result obtained for spray dried low fat honey based milk powder by Bansal *et al.* (2014) [3].

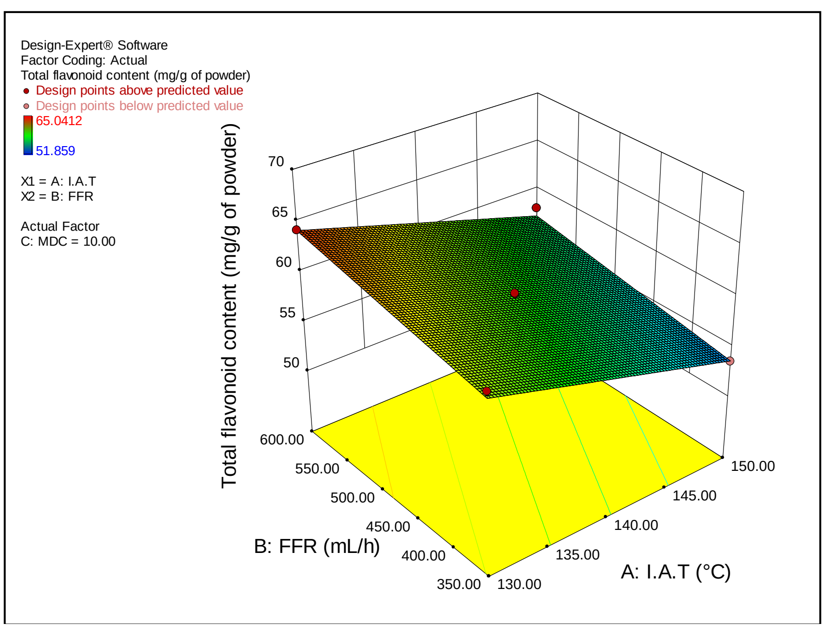

Fig 3: Response surface plot for total flavonoid content of spray dried papaya leaf powder as affected by feed flow rates (mL/h) and inlet air temperatures (ºC)

Color characteristics

Figure 4 shows L values of spray dried papaya leaf powder at different air flow temperature and feed rate. There was substantial decrease in L values of papaya leaf powder at inlet air temperature of 130 °C and 600 mL/h to 350 mL/h. However, no changes were found between 475 mL/h and 600 mL/h. At 140°C, L values were not altered by different feed rates. Similar result was also obtained at 150 °C.

At higher feed rate particles dried in a shorter time period so the exposure of particles with high temperature is less; hence sample powder is in bright colour. Whereas the time of exposure is long in case of low feed rate which resulted dark colour powder. The effect of inlet air temperature was insignificant on L value of papaya leaf powder when feed rate was 350 mL/h. At 475 mL/h feed rate, L values decreased remarkably with increasing inlet temperature from 130°C to 140°C. However, no change was occurred from 140°C to 150°C. At 600 mL/h, there was significant change in L value with increasing air flow temperature.

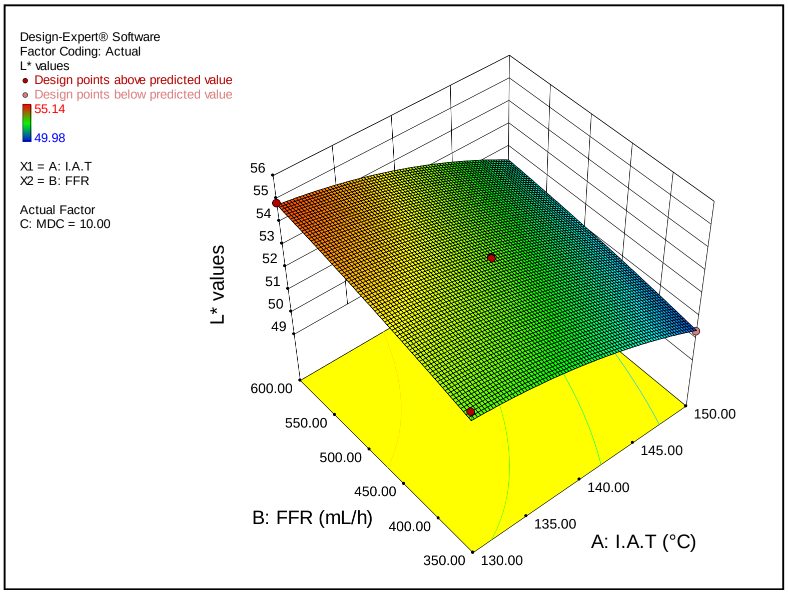

Fig 4: Response surface plot for L* values of spray dried papaya leaf powder as affected by feed flow rates (mL/h) and inlet air temperatures (°C)

Figure 5 shows the effect of air flow temperature and feed rate on a value of papaya leaf powder produced from 300 mL of papaya leaf juice. It was found that reduction of feed rate from 600 mL/h to 350 mL/h caused a significant decrease in a value of the papaya leaf powder produced at 130°C. However, there was no change in a value between feed rates of 350 mL/h to 475 mL/h, and 475 mL/h to 600 mL/h. Similar results were obtained when feed rate was increased from 350 mL/h to 600 mL/h at 140 °C and 150 °C inlet air temperature. At a feed rate of 350 mL/h, the values of a were almost same at 130°C and 140°C. However, there was a significant decrease when air flow temperature increased from 130°C to 150°C. Similar results were obtained for a value when air flow temperature was increased from 130°C to 140°C at 475 mL/h and 600 mL/h feed rates.

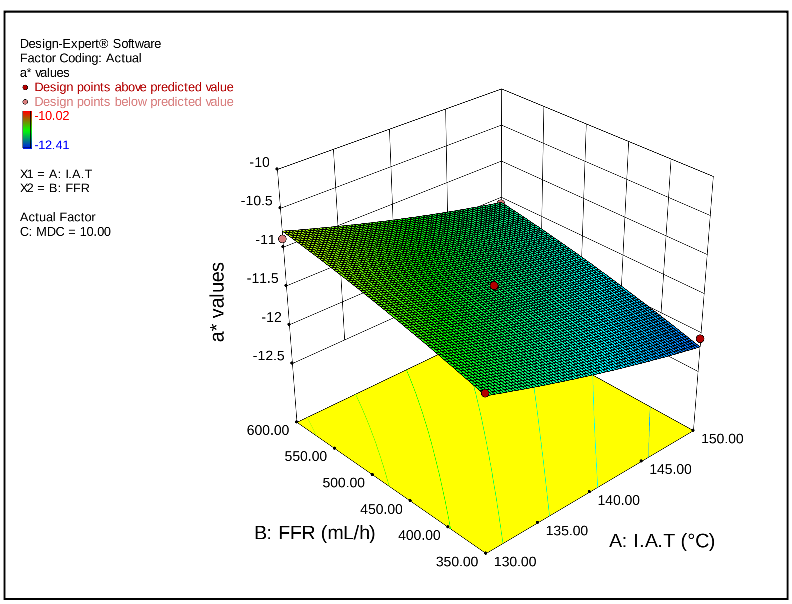

Fig 5: Response surface plot for a values of spray dried papaya leaf powder as affected by feed flow rates (mL/h) and inlet air temperatures (°C)

Figure 6 shows the effect of air flow temperature and feed rate on the b value of papaya leaf powder produced from 300 mL of papaya leaf juice. At 130°C, there was trivial effects on b values when feed rate was increased from 350 mL/h to 475 mL/h and subsequently to 600 mL/h. Similar results were observed with inlet air temperature of 140°C and 150°C. Different inlet air temperatures showed that at a feed rate of 350 mL/h, b values increased largely when temperature increased from 130°C to 150°C. However there was no change found between 130°C to 140°C. At feed rate of 475 mL/h and 600 mL/h, there was no remarkable change in b values with increasing inlet air temperature.

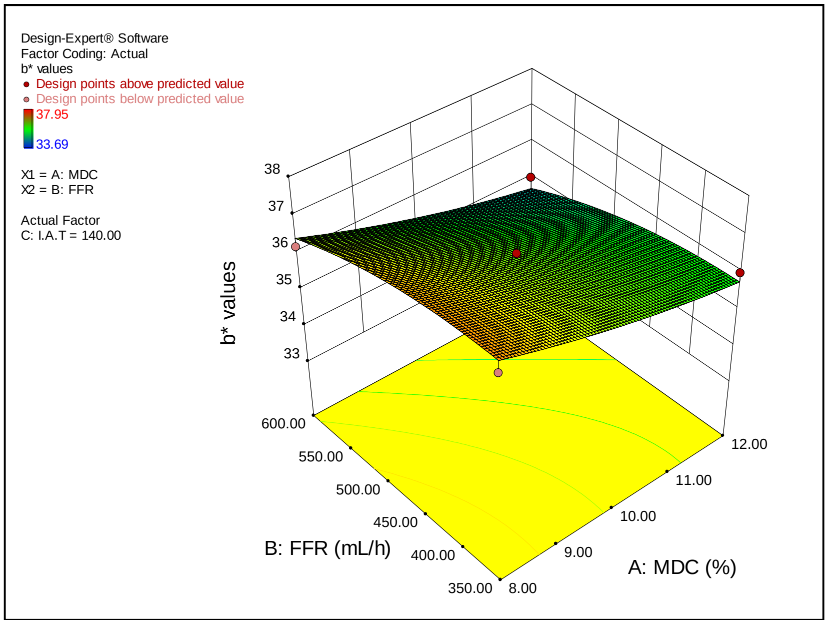

Fig 6: Response surface plot for b values of spray dried papaya leaf powder as affected by feed flow rates (mL/h) and inlet air temperatures (°C)

Conclusion

From the obtained results we can conclude that both inlet air temperature and feed rate significantly affect yield, moisture content, colour and total flavonoid content of spray dried papaya leaf powder. Increased feed rate in spray drying caused a significant decrease in yield with high moisture content. L value and a value of papaya leaf powder also increased with increased feed rate. Elevated inlet air temperature produced significantly high yield at feed rate of 600 mL/h. However, increased inlet air temperature resulted in reduced moisture content and a value.

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