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Process Optimization of Dehydrated Mango Slices

Ann Myril C. Tiu
Cebu Technological University- Main Campus
Correspondence: myril_chua@icloud.com

ABSTRACT

The main objective of this work is to determine the optimum levels of sucrose concentration, pluming time, and loading density in the dehydration process of Mango slices conducted at Cebu Technological University using Box-Benhken Design for Response Surface Methodology. Firm, rare-ripe mango was subjected to different 15 treatments. Treatments were subjected to sensory evaluation using 9-point hedonic scale and descriptive analysis. Drying time, percentage yield, and moisture content (%db) were subjected to Response Surface Regression Analysis (RSReg) to determine the degree of variance. Data revealed that the samples prepared using lower sucrose concentration have longer drying time than that of the samples using higher sucrose level. Percentage yield values of dehydrated mango slices ranged 11.40%-18.50% with an overall response mean of 14.27% or less that 20% recovery. Samples processed using higher sugar concentration and lesser loading density calculated to have higher cost. Although statistically insignificant at ($P \leq 0.01$), the differences in cents would be relatively be gigantic when converted to industrial production volume.

Keywords: Process Optimization, Response Surface Methodology, Box-Behnken Design, Dehydration

INTRODUCTION

Philippines being an agricultural nation regrettably only accounts for twelve percent (12%) of Philippines' GDP on agricultural sector as of 2013, according to the World Bank as reported by Philippine Statistics Authority (PSA).

Seventy-percent (70%) of the agricultural products in tropical and subtropical areas like Philippines were lost due to deficient market and inappropriate post-harvest technology. In developing countries with inadequately established thermal processing and low temperature facilities, food dehydration is the most appropriate preservation methods. In food preservation, food scientists aim at foods having moisture content from 10-20% where microorganism and enzymes are inhibited from spoiling it (Dennis, 1999). Nevertheless, the problems of quality changes in dried products should be taken into consideration. Irremediable changes to the texture quality, leading to decrease in volume, gradual cooking, and inadequate dehydration, color changes, shelflife and acceptability of consumer are some of the major concern in dried fruit processing as accounted by Konsue et.al (2002).

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Drying curve represents a drying characteristic of certain dried product at a specific velocity, temperature and pressure values. Understanding its idiosyncrasies associated with the drying of each unique product is extremely valuable. Drying process occurs in three different stages, which can be clearly defined as the initial, constant rate period and falling rate period (Charley, 1970). Product density also affects the drying rate. In general, as the drying rate substantially increases, it deceases the density. Damole (2000) discovered that the drying temperature is directly proportional to the drying rate of the dried product and inversely proportional with drying time. Moreover, Membrebe (2001) cited that the higher sugar level of the product the lower the constant rate period drying coefficient.

Mujumdar (1995) as cited by Konsue et.al (2002) studied on optimizing the pre-treatment methods of Mango (Mangifera indica L) to improve drying characteristic and minimize its quality changes using combined methods of proactive substance (glycerol, sucrose, and sodium chloride) preservative (potassium sorbate), anti-browning agent (calcium chloride). Such response radically improved shelflfe stability and preserving more attribute to that of fresh mango.

According to Myers & Montgomery (2001), the application of Response Surface Methodology in the manufacturing and industrialization where the quality characteristic of the product or process can be influenced by the several input variables. It is a useful statistical and mathematical technique in the product and process design, development, improvement and optimization.

Scarcity of systematic approaches to experimental designs leads to optimization methodologies carried out by changing one variable at a time while holding the others constant. This becomes an inefficient approach in locating the real optimum when all the other interaction of variables is present. Optimization is the process of modifying independent variables to identify the levels that achieve the best possible response. Different responses must be run concurrently.

The main objective of this work is to determine the optimum levels of sucrose concentration, pluming time, and loading density in the dehydration process of Mango (Mangifera indica L) slices conducted at DOST Food Technology Transfer Center of CTU Main Campus. This study utilized experimental method using Box-Benhken Design of Response Surface Methodology.

MATERIALS AND METHODS

Pre-drying treatments

Firm, rare-ripe mango was subjected to different sucrose concentration, pluming time and loading density adapting the basic process flow diagram of basic dried mango processing procedure from DOST 7 processing leaflets.

The color of the fruit was about 20% green and 80% yellow since maturity would affect the quality of the dried product. The fruit was washed with tap water, peeled, sliced along the

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lateral axis, was cut into ¼ thick by 1-inch in length approximately. The sliced mango was soaked with water and 0.1% sodium benzoate during the slicing process to prevent enzymatic reaction and discoloration. The slices were drained and cooked in different sugar syrup concentration: 20%, 40% and 60% with 0.1% sodium benzoate addition to every liter of sugar syrup. The different samples were soaked for 0-hours, 12-hours and 24-hours at different levels of sugar syrup. After each particular plumbing duration, the samples were drained. The drained samples were weighed to a determined loading density in different levels: 4kg/m^2, 6 kg/m^2 and 8 kg/m^2.

Dehydration Process

Mechanical Cabinet Dryer was utilized in this study. The dryer was stabilized for an hour ay 60-70^{0}c at ambient RH (Damole, 2000). The area of area of the drying tray was 0.3716 m^2. The required amount of sample for each treatment was spread evenly on the drying tray. The moisture content in percent dry basis (%db) is determined at every drying time interval of an hour until the product would dry at specified moisture content approximately 17-18 % dry basis. The data gathered was used to determining the drying time per treatment for each drying process.

Post-Dehydration Treatments

The samples were subjected to sweating to stabilize the moisture content of the dehydrated products. It was then screened to remove unwanted sizes. The dehydrated product was then checked to remove physical contamination.

Statistical Analysis

The degree of variance was obtained using Analyses of Variance (ANOVA) at 1% level of significance.

RESULTS AND DISCUSSION

Table 1 shows the processing parameters evaluated during the processing of dehydrated mango slices were drying time, percentage yield and estimated processing cost generated per treatment.

Table 1. Evaluated Processing Parameters of Dehydrated Mango Slices[a]

Treatment No.	Drying Time [a] (Hour)	Yield [b] (%)	Est Processing Cost [c] (PhP)
1	14.17	15.60	802.98
2	14.58	14.10	796.03
3	14.25	12.40	820.40
4	12.35	14.60	772.74
5	14.92	15.50	804.42
6	14.67	17.10	802.06

7	12.10	15.40	760.24
8	12.80	16.40	786.46
9	13.45	11.50	787.14
10	13.67	11.40	788.82
11	13.27	15.40	781.31
12	13.50	15.20	788.29
13	13.25	17.50	783.38
14	13.10	17.20	791.59
15	13.35	18.50	776.55
RESPONSE MEAN	**13.60**	**14.27**	**789.49**

Drying time was determined when the final % moisture content of the product ranged between 17-18% dry basis (%db).
[b] Percentage Yield was determined when the final % moisture content of the product ranged between 17-18% dry basis (%db).
[c] Estimated Processing Cost was determined using the actual price of commodity during the conduct of this study.

Data revealed that the samples prepared using lower sucrose concentration have longer drying time than that of the samples using higher sucrose level. Samples prepared from 20% sucrose concentration, 12 hours pluming time and 3 kg/m^2 loading density generated the longest processing time of dehydrated mango slices. However, treatment made from 40% sucrose concentration, 12-hours and 3 kg/m^2 loading density obtained the shortest processing time of 12.10 hours. This implied that the sucrose concentration has a significant influence on the drying time generated in processing the dehydrated mango slices. Water molecule tends to move from less osmotically active solute to a more concentration causing the water inside the cell wall of the fruit to diffuse thereby decreasing the time necessary to obtain the desired ranged of %db. The residual moisture content of dried product need to reach 14-18% to avoid the stickiness feel which is most often critical issue in dehydrated products (Diamante, L.M & P.A Munro, 1994). Response surface regression analysis revealed that the drying time generated was significantly affected ($P \leq 0.01$) by linear interactions between the different levels of sucrose concentration. Drying rate should a positive correlation with temperature while deceased with increasing loading density (Papu et,al., 2014). Percentage yield values of dehydrated mango slices ranged 11.40%-18.50% with an overall response mean of 14.27% or less that 20% recovery. The response was not affected by the parameters studied. In addition, the estimated cost in the processing ranged from P760.24 to P820.40 with an overall response mean of P789.50. Samples processed using higher sugar concentration and lesser loading density calculated to have higher cost. Although statistically insignificant at ($P \leq 0.01$), the differences in cents would be relatively be gigantic when converted to industrial production volume. Calculations in estimating the processing cost were based on the yield recovery (kg) after drying process.

CONCLUSION

Sucrose concentration and drying time in dehydrated product processing is positive adverse effect in nature at specific saturation point. Increasing sucrose concentration within the experimental levels being considered in the study can reduce drying time. Drying rate is reduced with increase loading density being considered experimental range. In addition, although statistically insignificant, the small differences in cost can have a dynamic impact on the processing cost as a substance in industrial production scale.

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