International Journal of Tropical Agriculture
Volume 40, Numbers (3-4) • 2022 : pp. 461-472
ISSN: 0254-8755

Optimization of Avocado Milk Shake Powder By Spray Drying Process Parameters

Pavan kumar[1], G. V. Mohithkumar[2] , Suresha, K. B.[3], Viresh Kumargouda[4] and Usha Ravindra[5]

[1]*M. Tech (Agri. Engg.) Department of Processing and Food Engineering, College of Agricultural Engineering, UAS, GKVK, Bengaluru-560065*
[2]*Associate Professor, Department of Agricultural Engineering, College of Sericulture, Chintamani - 563125*
[3]*Associate Professor (Dairy Technology), AICRP on PHET (ICAR), UAS, GKVK, Bengaluru-560065*
[4]*Assistant Professor (Processing and Food Engineering) Dept. of Processing and Food Engineering, College of Agricultural Engineering, UAS, GKVK, Bengaluru-560065*
[5]*Professor Dept. of Food Science and Nutrition, UAS, GKVK, Bengaluru-560065*

Abstract: The Box – Behnken Design technique from Response Surface Methodology (RSM) were used to investigate the effects of spray drying conditions on avocado milk shake powder and analyzed physioco chemical parameters moisture content, water activity, loose bulk density, tapped bulk density, colour and pH. The spray drying independent variables and ranges are inlet air temperature (140, 150 and 160), feed flow rate (10, 11 and 12 rpm) and total solids (17, 19 and 21) The complete design was executed in random order and comprised of 15 combinations Experimental data were analysed by multiple regression equation to fit a second-order polynomial model. The coefficients of determination and analysis of variance (ANOVA) were used to evaluate the goodness of fit of the regression model. The best spray drying conditions within the experimental ranges for minimum powder moisture content, water activity, loose bulk density, tapped bulk density,colour ($L^{*}, a^{*} b^{*}$)and pH varies from 4.32%, 0.200, 0.371, (91.99, -0.523, 11.65) and 6.32, respectively with the optimised conditions of inlet air temperature, feed flow rate and slurry concentration of 150, 11 rpm and 19%, respectively. The desirability of optimised condition is about 0.619 with Design Expert- 12.0.3.0

1. INTRODUCTION

Avocados are native to Central and South America they have been cultivated in this region since 8,000 BC. In the mid-17th century, they were introduced to Jamaica and spread through the Asian tropical regions in the mid-1800s. According to scientific classification, the avocados belong, to the kingdom: plantae, family: lauraceae, genus: persea, species: americana with bionomial name Persea americana Mill (Orhevba et al., 2011).

The avocado is useful in human nutrition as a source of various nutrients and especially as source of energy and monounsaturated fatty acids. At about 70% of total fruit weight correspond to the pulp with an average of 6.94 g of carbohydrates, 17.34 g of fat, 2.08 g of proteins, 2.72 g of fibers, in 100 g of fresh pulp (Favier et al., 1999).

Fruit milk shake is dried using a variety of methods, including hot air drying, freeze drying, drum drying, foam mat drying, spray drying, and vacuum drying. The process of spray drying is widely employed in the food industry to turn a variety of fruit milk shake into powder. spray drying preserves nutritional properties, producing powders of high quality. By applying heat to the feed product and regulating the humidity of the drying medium, spray drying works by removing moisture, the feed is sprayed into a heated environment to encourage the evaporation of moisture, which improves the drying rate (Anandharamakrishnan et al., 2007).

Article History: Received: 29 November 2022; Revised: 20 December 2022; Accepted: 10 December 2022

The spray dryer operating conditions and response variables are very important to produce the maximum powder efficiency and yield. These response variables were selected as they were important indicators of microsphere functionality and process efficiency. Factors that can significantly affect the spray drying process and product characteristics include the feed rate, atomizing wheel speed, dryer inlet and outlet air temperatures and drying air humidity. Spray dryer inlet temperatures had a more direct effect on the drying process, with droplet drying rates positively related to inlet air temperatures used (Phisut, 2012).

RSM is a collection of mathematical and statistical techniques for empirical model building that is an efficient tool for effect study and does not demand a lot of experimental data (Cornell, 1990). RSM were successfully used to link one or more responses to a set of variables when firm interaction was known. This method is an effective and successful technique used to obtain the best value and most influencing variables for a few sets of variables that affect the value of any response. Response surface methodology (RSM) is a useful statistical technique for investigating complex processes and has been widely adopted in food science research. RSM has been successfully applied to optimise conditions in several food processes.

MATERIALS AND METHODS

The main raw material, avocado was collected from organic farming at UAS, GKVK, Bengaluru. Commercially available "HERITAGE" brand skim milk powder manufactured by Heritage Foods Limited was procured from a local market in Bengaluru.

Preparation of Avocado Fruit Milk Shake

The avocado fruits were cleaned with water. Later the fruits were peeled to remove the outer skin and cut into small slices using stainless steel knife. The sliced fruits were made into fine pulp using a kitchen blender. Then pulp, skimmed milk powder and honey (7 per cent, 5 per cent and 3 per cent) were added to skimmed milk to form milk shake show in Fig 1. After it was filtered through a folded muslin cloth. The filtered avocado milk shake was used for further sample preparation for spray dryer as shown in plate 1.

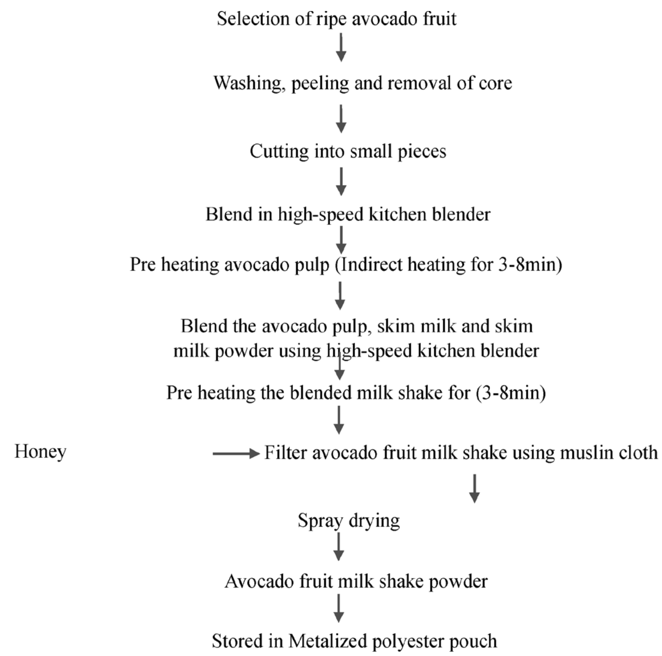

Fig. 1: Flow chart for the preparation of Avocado fruit milk shake powder

Experimental Design

The optimization of process parameters for spray-dried avocado milk shake powder is

Table 1: Treatment combinations for spray drying of Avocado milk shake powder

Sl. No.	*Treat-ments*	*Inlet temperature*	*Feed flow rate (rpm)*	*Total solid (%)*
1	$(TRS)_1$	160	12	19
2	$(TRS)_2$	160	10	19
3	$(TRS)_3$	150	10	21
4	$(TRS)_4$	150	10	17
5	$(TRS)_5$	150	11	19
6	$(TRS)_6$	150	11	19
7	$(TRS)_7$	160	11	17
8	$(TRS)_8$	140	11	17
9	$(TRS)_9$	160	11	21
10	$(TRS)_{10}$	140	10	19
11	$(TRS)_{11}$	140	12	19
12	$(TRS)_{12}$	150	12	17
13	$(TRS)_{13}$	140	11	21
14	$(TRS)_{14}$	150	11	19
15	$(TRS)_{15}$	150	12	21

Note:

T1, T2 and T3 indicate 140, 150 and 160 of inlet air temperature, respectively.

R1, R2 and R3 indicate 10, 11 and 12 of Feed flow rate concentration, respectively.

S1, S2 and S3 indicate 17.5, 19 and 20.5 of total solids, respectively carried out using Design Expert version 12.0.3.0 software (Trial version StatEase). The Box-Behnken design was used to optimise three levels of each independent parameter, such as inlet air temperature (140, 150 and 160 °C), feed flow rate (10, 11 and 12 rpm), and slurry concentration (17, 19 and 21%).

Plate 1: Tall type spray drier

Analysis of spray dried avocado milk shake powder

The spray dried avocado milk shake powder was analyzed for moisture content, water activity, bulk density and pH.

Moisture Content: The moisture content of the spray-dried powder was determined by drying the powder sample at the temperature of 105 in the hot air oven until a constant weight was obtained (AOAC, 2000).

$$Moisture\ content\ (\%\ w.b.) = \frac{W_1 - W_2}{W_1} \times 100$$

Where,

W_1 = Initial weight of the sample, g

W_2 = Final weight of the sample, g

Water Activity

Water activity meter was used for the measurement of water activity of the prepared sample. Its reading is precise, providing ±0.003 accuracy. For the water activity determination (Hygro Lab C1 bench-top meter), was used.

Bulk Density

The bulk density of spray dried Avocado milk shake powder obtained from different treatments was measured according to the procedure described by Caparino *et al.* (2012)

pH

The pH of spray dried avocado milk shake powder was measured by using digital pH meter. One-gram powdered sample was weighed and it was dissolved in a 10 ml of distilled water in a beaker, then the electrode of the pH meter was dipped in the sample under test. The enter key was pressed to show the pH value and temperature of sample simultaneously. For next sample measurement, electrode was removed and washed properly with distilled water, then the above procedure was followed and reading was taken as the pH of the next sample (Arab *et al.*, 2011).

$$Loose\ Bulk\ density\ (kg/m^3) = \frac{Weight\ of\ the\ Powder\ (g)}{Loose\ Powder\ Volume\ (mL)}$$

$$Tapped\ Bulk\ density\ (kg/m^3) = \frac{Weight\ of\ the\ Powder\ (g)}{Tapped\ Powder\ Volume\ (mL)}$$

Colour

Bench-top spectrophotometer (Model: Konica Minolta; spectrophotometer CM-5) was used for the measurement of colour of avocado milk shake powder. It works on the principle of focusing the light and measuring energy reflected from the sample across the entire visible spectrum. The 3-dimensional scale L^*, a^* and b^* was used.

Development of model

Software fitted experimental data to compute models of responses and their regression coefficients were obtained. Both linear and second order quadratic models were employed to correlate the independent process parameters.

Statistical significance of the terms/coefficients in the regression equation was examined by analysis of variance (ANOVA) for each response. The significance of all terms in the polynomial was judged statistically by computing the F-value. The adequacy of the model was tested considering the coefficient of multiple determination R^2. The quadratic response surface analysis was based on multiple linear regressions considering linear, quadratic and interaction effects according to the equation below:

$$Y=b_0+\Sigma aixi+\Sigma aijxixj+\Sigma aiixi$$

Where, Y is the response value predicted by the model; b0 is offset value, ai, aij and aii are main (linear), interaction and quadratic coefficients, respectively. The adequacy of the models was determined using model analysis; lack-of-fit test and coefficient of determination (R^2) analysis. For model to be suited, R^2 should be at least 0.80 for a good fitness of a response model (Mirhosseini *et al*., 2009).

3. RESULT AND DISCUSSION

The moisture content were negatively related to the linear term inlet air temperature, total solids and feed flow rate as shown in Fig 2. The moisture content of spray dried Avocado milk shake powder decreased when the inlet air temperature increased because the amount of heat supplied to the particles increased which shown in (Table 2). Similar result reported by (Vennila *et al.,* 2020) in Musk melon milkshake powder varied from 3.2 to 4.19 per cent and (Pandey *et al*., 2020) Were reported that moisture content of the butter fruit milk shake powder by freeze dried was 2.90 per cent.

The pH of spray dried avocado milk shake powder at different treatments as shown in Table 2. The values are varied from 6.22 to 6.43 per cent for different levels of inlet temperature, feed flow rate and total solids which are graphically represented by RSM as shown in Fig. 3.

Similar result found that is varied from 5 to 5.39 of pH which is observed in muskmelon fruit milkshake powder by spray dried (Vennila *et al.,* 2020).

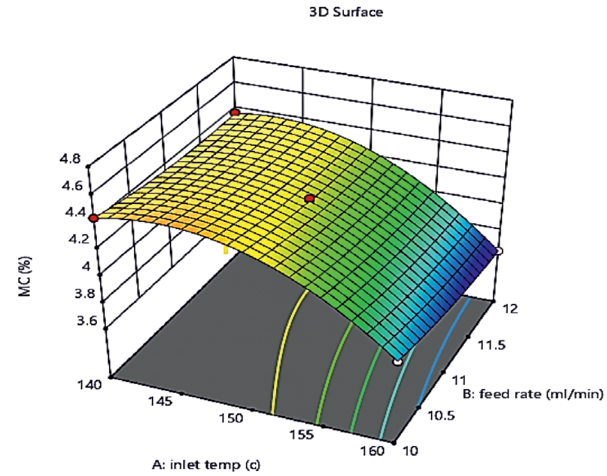

Fig. 2: Processing parameters of the moisture content of spray dried avocado milk shake powder

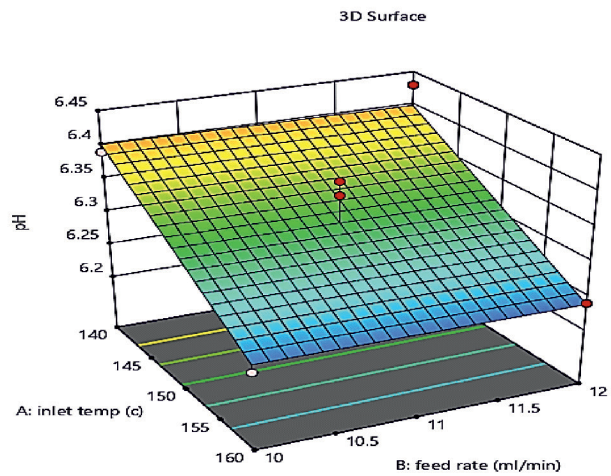

Fig. 3: Processing parameters of the pH of spray dried avocado milk shake powder

The water activity was negatively related to both the linear term inlet air temperature, total solids and feed flow rate as shown in Fig 4. The water activity of spray dried Avocado milk shake powder decreased when the inlet air temperature increased because the amount of heat supplied to the particles increased values are shown in Table 2. Similar result reported by that values below 0.6 can be considered microbiologically or chemically stable because the amount of free water available for biochemical reactions is low (Dantas *et al*., 2018).

The L^* color was negatively related to both the linear term inlet air temperature, total solids and feed flow rate as shown in Fig 5. The L^* color of spray dried Avocado milk shake powder decreased when the inlet air temperature

Table 2: Effect of processing conditions on physico-chemical parameters of spray dried avocado milk shake powder

Runs	*Independent variables*			*Dependent variables*							
	IT	*FFR (rpm)*	*TS (%)*	*MC (%)*	*pH*	a_w	L^*	a^*	b^*	*LBD (g/cc)*	*TBD (g/cc)*
1	160	12	19	3.63	6.24	0.2182	90.93	-0.694	12.04	0.3021	0.6389
2	160	10	19	3.84	6.23	0.2199	91.05	-0.5945	12.08	0.3019	0.6312
3	150	10	21	4.32	6.29	0.2397	92.85	-0.421	11.43	0.4102	0.5189
4	150	10	17	4.62	6.35	0.2363	91.2	-0.4196	11.48	0.3903	0.5682
5	150	11	19	4.31	6.36	0.2181	92.03	-0.5241	11.44	0.3789	0.5187
6	150	11	19	4.26	6.38	0.2181	92.06	-0.5236	11.68	0.3321	0.5208
7	160	11	17	3.89	6.22	0.2024	91.75	-0.8073	12.12	0.2899	0.6321
8	140	11	17	4.41	6.41	0.2892	93.72	-0.865	11.02	0.4821	0.4586
9	160	11	21	3.64	6.27	0.2201	92.61	-0.795	12.22	0.3232	0.6317
10	140	10	19	4.44	6.39	0.2782	91.67	-0.3865	11.21	0.4722	0.4798
11	140	12	19	4.37	6.43	0.2872	92.56	-0.6055	11.45	0.4545	0.4954
12	150	12	17	4.33	6.31	0.2405	93.24	-0.799	11.72	0.3134	0.5199
13	140	11	21	4.44	6.37	0.2609	92.84	-0.4405	11.38	0.4327	0.5012
14	150	11	19	4.32	6.28	0.2289	92.05	-0.524	11.8	0.3321	0.5357
15	150	12	21	4.32	6.27	0.2413	91.57	-0.3605	11.85	0.3298	0.6039

Note: IT: Inlet temperature; FR: Feed flow rate; TS: Total solids; MC: Moisture content; Aw: Water activity; PH; Color (L^*, a^*, b^*); LBD: loose bulk density; TBD: Tapped bulk density; OAA: Overall acceptability.

increased reason is due to the higher inlet temperature that causes more water (moisture) to be removed during the drying process, resulting in the concentration of the pigments and whiteness due to skim milk. Similar result reported by (Pandey *et al.*, 2020) that values the addition of milk and maltodextrin in avocado pulp leads to brighter, less green and less yellow L^*(77.62), a^*(-2.22), b^*(19.63) butter fruit milkshake powder is obtained.

Because avocado milk shake honey is exposed to higher temperatures during spray drying, the a^* colour of spray-dried Avocado milk shake powder increased slightly as the inlet air temperature increased, and the lightness of the powder decreased as shown in Fig 6. This means that the colour of the powder has become darker at a higher inlet temperature. Similar result reported by that values Avocado is naturally green in color, so the value of a^* is negative. However, the addition of milk and maltodextrin in avocado pulp leads to brighter, less green and less yellow L^* (77.62), a^* (-2.22), b^* (19.63) for freeze dried butter fruit milkshake powder is obtained (Pandey *et al.,* 2020). Similar results reported by Abhilasha (2018) that the increase in the inlet air temperature, increased a^* value of the spray dried pineapple juice powder. It may be the effect of some nonenzymatic browning reaction such as caramelization and maillard reactions during the spray drying

Increase in the inlet air temperature results in decrease in b^* value of the avocado milkshake powder due to the degradation of color of the spray dried samples at higher temperature which is shown in Fig 7. Similar result reported by (Pandey et al., 2020) that values the addition of milk and maltodextrin in avocado pulp leads to, brighter, less green and less yellow L^* (77.62), a^* (-2.22), b^* (19.63) butter fruit milkshake powder.

The loose bulk density was negatively related to both the linear term inlet air temperature, total solids and feed flow rate as shown in Fig 8. The loose bulk density of spray dried Avocado milk shake powder decreased when the inlet air temperature due to the higher evaporation rate, resulting in a more porous powder which shown in Table 2. The final spray dried avocado milk shake powder varies from 0.2899 to 0.4821 g/cc.

Similar result reported Pandey *et al.* (2020) that values the addition of milk and maltodextrin in avocado milk shake powder by freeze dried the values varies from 0.492 to 0.521 g/cc.

The high drying temperatures (140, 150 and 160 °C) significantly reduced the tapped bulk density of the powder. Correspondingly the high feed flow and total solids increased the tapped bulk density of the powder product values are shown in (Table .1) The Tapped bulk density was negatively related to both the linear term inlet air temperature, total solids and feed flow rate as shown in Fig 9. The tapped bulk density of spray dried Avocado milk shake powder decreased when the inlet air temperature due to the higher evaporation rate, resulting in a more porous powder. Birchal *et al.* (2005) also detected that tapped bulk density of milk powder varied from 0.379 to 0.636 kg/m3, and it significantly decreased as the inlet air temperature increased.

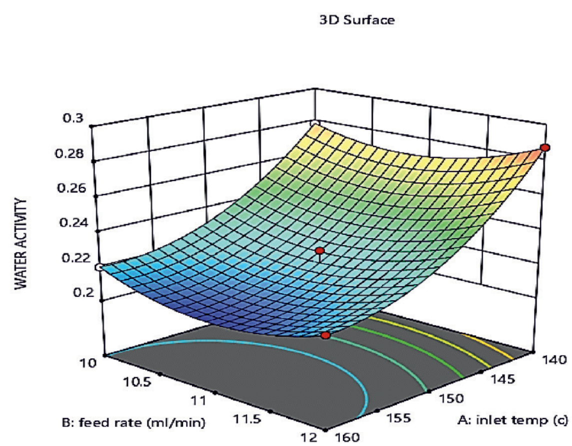

Fig. 4: Processing parameters of the water activity of spray dried avocado milk shake powder

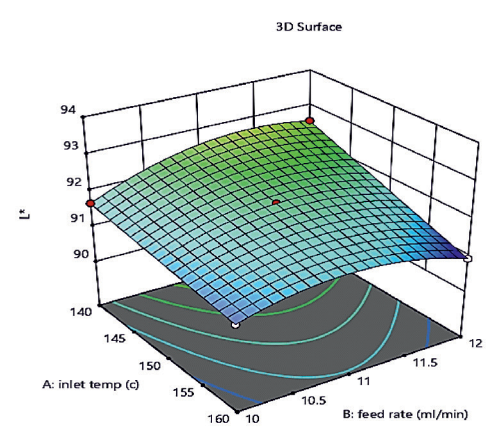

Fig. 5: Processing parameters of the colour value L^* of spray dried avocado milk shake powder

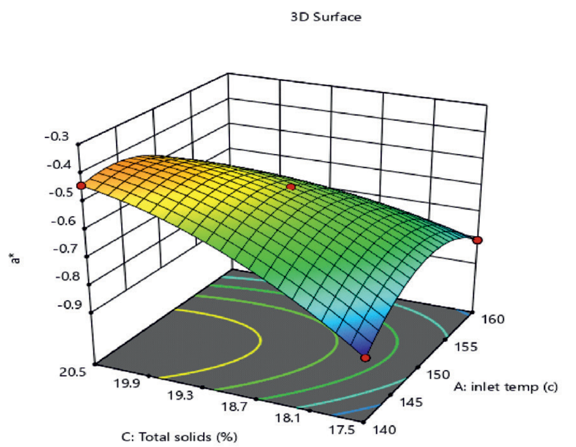

Fig. 6: Processing parameters of the colour value a^* of spray dried avocado milk shake powder

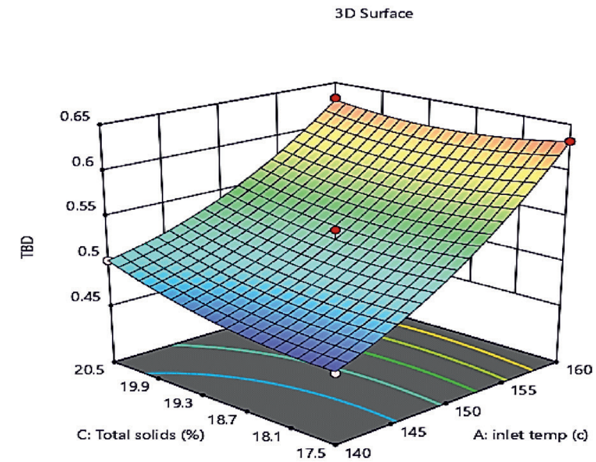

Fig. 9: Processing parameters of the tapped bulk density of spray dried avocado milk shake powder

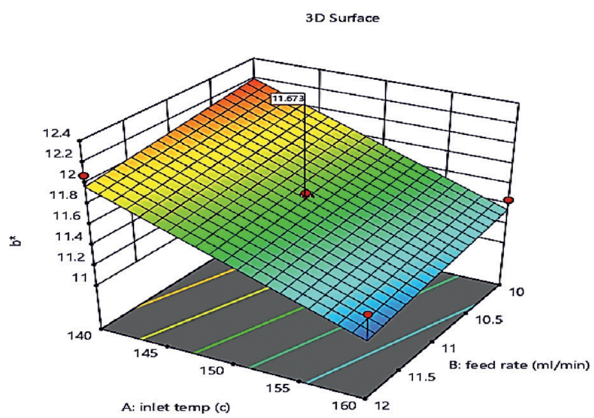

Fig. 7: Processing parameters of the colour value b^* of spray dried avocado milk shake powder

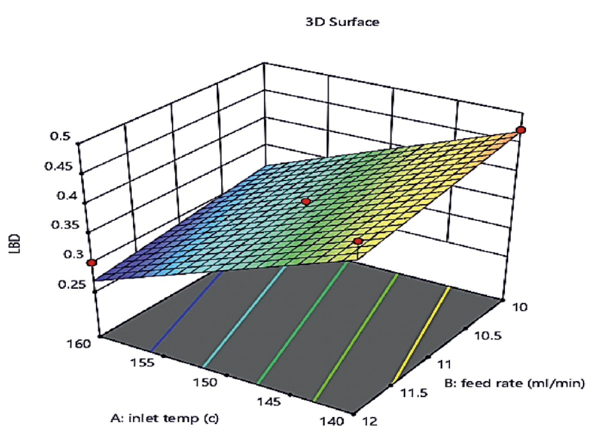

Fig. 8: Processing parameters of the loose bulk density of spray dried avocado milk shake powder

Numerical Optimization of process parameters for spray dried avocado milk shake powder

Optimization of the three process variables namely; inlet air temperature (140, 150, and 160), feed flow rate (10, 11 and 12 rpm) and total solids (17, 19 and 21 %) was performed in design expert software version 12.0.3.0. The objective of the optimization was to obtain the combinations of the three process parameters, which produced the desired powder quality. The optimum conditions for the desired product were decided by evaluating all the responses simultaneously. In the present investigation, the independent variables were kept within the range and dependent variables were chosen as either maximum or minimum. (Table 3) shows the analysis of ANOVA table effect of different inlet air temperatures, feed flow rate and total solids on optimization of spray dried avocado milk shake powder achieved from Box-Behnken Design Expert Software 12.0.3.0

Verification of the predicted variables

The optimum response values were tested using the recommended optimum conditions of the variables and was also used to validate the experimental and predicted values of the responses. The experimental sample had the optimum process conditions of inlet air temperature, feed flow rate and their total solids of avocado milk shake powder 150, 11 rpm and 19 %, respectively as shown in plate 2. This optimized parameter was carried out thrice and the predicted and actual values of the responses and the percentage variation at the optimized condition of experiments are presented in Table 4. The predicted moisture content, water activity, pH, color values (L^*, a^*, b^*), loose bulk density and tapped bulk density value were found to be 4.30 per cent, 0.220, 6.31, 91.99, -0.523, 11.65, 0.369 g/cc and 0.526 g/cc respectively. The actual moisture content, water activity, pH, color values (L^*, a^*, b^*), loose bulk density and tapped bulk density value were found to be 4.322 per cent. 0.375 g/cc, 0.236, 6.42, 93.11, -0.501, 11.35, 0.371 g/cc and 0.528 g/cc respectively.

Table 3: Analysis of variance (ANOVA) of the process parameter of the spray dried avocado milk shake powder

Factors	***MC***	***pH***	a_w	**L***	**a***	**b***	***LBD***	***TBD***
Model	1.3*	0.0522*	4.59385*	1.43*	0.4062*	1.56*	0.0526*	0.0535*
A	0.8845*	0.0512*	0.03251*	0.9660*	0.0440*	1.45*	0.0487*	0.0448*
B	0.0406*	0.0020*	0.00605*	0.0313*	0.0508*	0.099*	0.0038*	0.0004*
C	0.0351*	0.0010*	0.85151*	0.0392	0.0955*	0.0136*	0.0001*	0.0007*
AB	0.0049*	-	0.00063	0.0012*	0.0036	-	-	0
AC	0.0196	-	0.0121	0.0072*	0.0425	-	-	0.0005*
BC	0.021*	-	0.00303*	0.0342	0.0484*	-	-	0.0044*
A2	0.2585	-	1.66987	0.3079*	0.0689*	-	-	0.0014*
B2	0.0053*	-	0.86852*	0.0036	0.0301*	-	-	0.0010*
C2	0.0146*	-	1.69479*	0.0187*	0.0163	-	-	0.0005*
Lack of fit	0.0011	0.008	0.00032	0.001	4.25	0.1833	0.0077	0.0001
R2	0.9976	0.7937	0.9998	0.9963	1	0.878	0.9963	0.9961
Pre R2	0.9832	0.6609	0.9986	0.9817	1	0.7594	0.9817	0.9809
Std. Devi	0.0251	0.0351	0.0136	0.0324	0.0002	0.1402	0.0324	0.0065
C.V.%	0.5955	0.5558	0.1713	0.7696	0.0327	1.2	0.7696	1.18

The desirability values of the minimum and maximum were configured as 0 and 1, respectively. The maximum desirability function obtained was taken as the optimum operating condition (Sathyashree *et al.,* 2016). The experimental sample had the optimum process conditions using total solids of 18.87 (≈19) per cent and temperature of 150.287 (≈150 °C) and feed flow rate 10.877 rpm (≈11 rpm) with desirability of 0.619 as shown in Fig. 10.

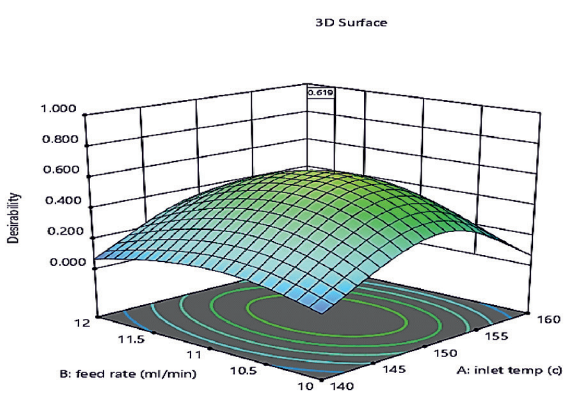

Fig. 10: Desirability of optimum processing parameters of spray dried avocado milk shake power

Plate 2: Optimized spray dried avocado milk shake powder

Table 4: Predicted and actual values of responses for optimized spray dried Avocado milk shake powder

Sl. No.	*Response*	*Prediction*	*Actual*
1	Moisture Content (%)	4.30	4.32 NS
2	Water activity	0.22	0.20NS
3	pH	6.31	6.32NS
4	L^*	91.99	93.11NS
5	a^*	-0.523	-0.501 NS
6	b^*	11.65	11.35NS
8	Loose bulk density (g/cc)	0.369	0.371NS
9	Tapped bulk density(g/cc)	0.526	0.528NS

NS = Not Significant.

Storage Studies of optimized spray dried Avocado milk shake powder

Table 2: Effect of storage days on moisture content, water activity, bulk density and pH of Spray dried Avocado milk shake powder product

Packaging material	*Storage period*	*Moisture content*	*Water activity*	*Bulk density*	*pH*
Metalized polyester	0	4.32	0.221	0.371	6.32
	15	4.52	0.251	0.387	6.21
	30	4.83	0.280	0.398	6.18
	45	4.92	0.309	0.421	6.11
	60	5.11	0.317	0.435	6.07
	75	5.26	0.368	0.447	6.02
	90	5.37	0.390	0.465	6.01
	CD@5%	0.452	0.039	0.042	N/A
	SEm ±	0.148	0.013	0.014	0.190

CD: Critical Difference, SEm ±: Standard Error of mean

For a three-month storage period the moisture content was initially 4.32 per cent. The moisture content steadily increased during the course of the storage period shown in Fig 2. At the end of the three-month storage period, it was shown to have grown from 4.32 to 5.37 per cent it is due to ingress of honey which cause the hygroscopic in nature which leads to increase the moisture content over a time in packaged material and moisture revealed that the packaging material and storage time had a significant (P≤ 0.05) impact on the moisture content of spray dried avocado milk shake powder product. This values are consistent with the (vennila *et al.*, 2020).

The water activity were increased slightly due to ingress changes of chemical during storage values are shown above (Table 2) which varied from 0.221 to 0.390 shown as in Fig 3. Similar results obtained by progressive increase in the water activity of instant mango milk shake powder ranging from 0.241on 0th day to 0.330 on 90th day (Singham *et al.* 2014).

.For a three-month storage period the bulk density was initially 0.371 g/cc. The bulk density steadily increased during the course of the storage period as shown in Fig 4. At the end of the three-month storage period, it was shown from 0.435 to 0.465 . bulk density revealed that the packaging material and storage time had a significant (P≤ 0.05) impact on the bulk density of Spray dried Avocado milk shake powder product. Similar results obtained by Priyanka (2018) were observed Bulk density of mango milk powder increased with the storage period while initially it was observed that 0.71 then gradually increased during storage Moist powder exhibited higher angle of repose (mainly due to cohesion), despite the fact that the angle of internal friction usually decreases with increase in moisture level.

After every 15 days of storage for a three-month period, the pH of spray-dried avocado milkshake powder samples packaged in metalized polyester packing film was evaluated as shown in Fig 5. For a three-month storage period the water activity was initially 6.32. The pH steadily decreased during the course of the storage period. At the end of the three-month storage period, it was shown from 6.32 to 6.01. pH revealed that the packaging material and storage time had a significant (P≤ 0.05) impact on the pH of Spray dried Avocado milk shake powder product. Similar results obtained by Priyanka (2018) there was progressive slightly decrease in the pH of instant mango shake powder by spray dried ranging from 6.08 on 0th day to 5.70 on 90th day

Effect of packaging material and storage days on sensory characteristics

The sensory acceptability of the Avocado milk shake powder were assessed on each withdrawal for 15 days interval and recorded in terms of color, appearance, consistency, flavour, mouth

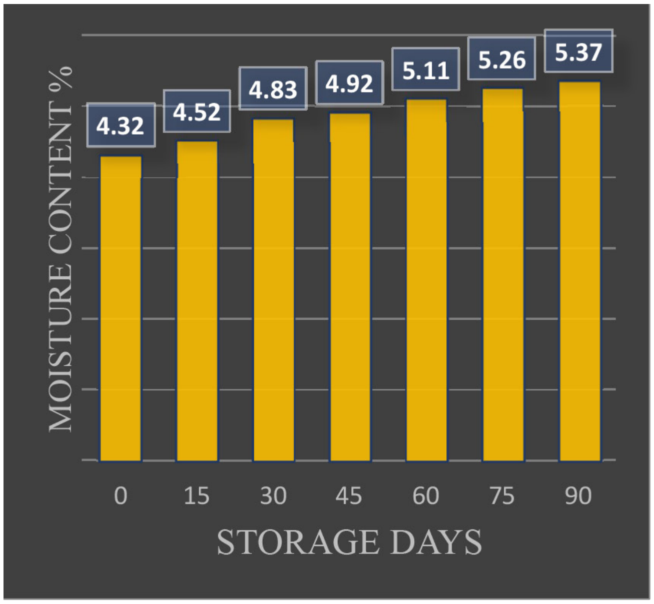

Fig 2: Effect of moisture content on storage days

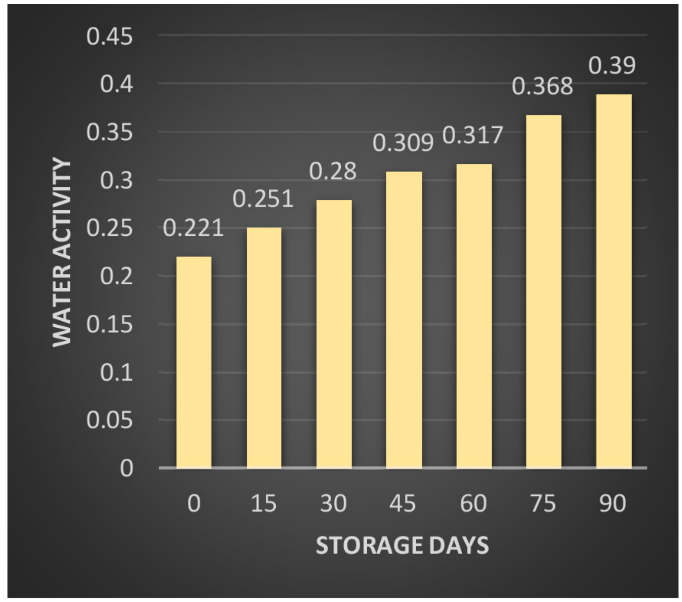

Fig 3: Effect of water activity on storage days

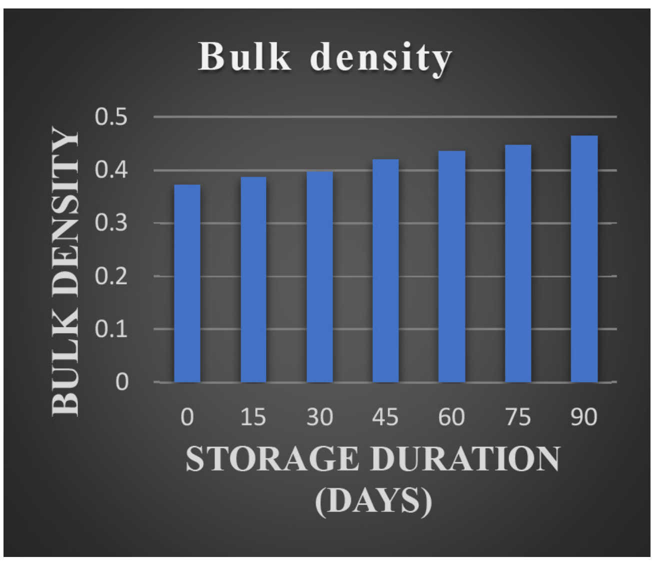

Fig 4: Effect of on bulk density storage days

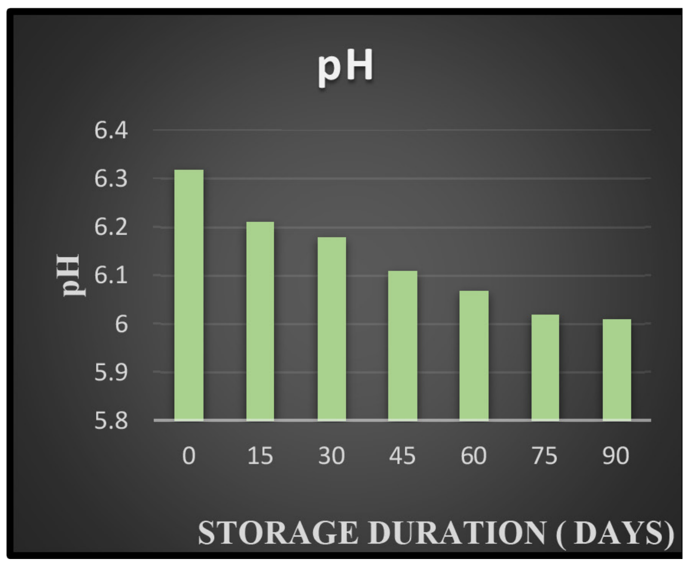

Fig 5: Effect of on pH storage days

feel and overall acceptability three months storage period.

Effect of storage on sensory scores of avocado milk shake powder stored in metalized polyester (mp) film

The sensory scores for the optimized Avocado milk shake powder product were stored in metalized polyester packaging cover are presented in Table 3. It was observed that, with increasing storage period, mean sensory sores for overall acceptability of the Avocado milk shake powder declined from 8.02 to 6.44 at the end of the storage period, the sensory scores for color, appearance, consistency, flavour, mouth feel and overall acceptability of Avocado milk shake powder product were rated as 8.03, 8.8, 7.5,7.4, 8.01 and 8.02, respectively. The highest average overall acceptability was observed at 0, 1 and 2 months of storage indicated that Avocado milk shake powder were acceptable up to two months of storage. Decreasing trends ($p < .05$) were observed for all the sensory attributes like, color, appearance, consistency, flavour, mouth feel and overall acceptability of products during storage.

Effect of packaging material and storage days on microbial load

The microbiological analysis was carried for the Avocado milk shake powder packed in metalized polyester packaging film using Total plate count (TPC) method.

Effect of microbial load on avocado milk shake powder during storage days

Microbial load was calculated in terms of cfu/g and presented in Table 4. During the storage period of three months yeast and molds were detected and *Coliforms* were found to be absent. Bacterial count were found to increase in the range of 0.12 to 3.1 X 10^4 cfu/g. Yeast and mold were not detected up to first month of storage period. From the 75th day of storage, yeast and molds were detected in the range of 1.2 X 10^0 to 2.3 X 10^0 cfu/g. It was clear that, bacterial count and fungal count increased during storage days.

The TPC load of Avocado milk shake powder the kept in metalized polyester pouches at ambient storage conditions increased significantly ($p \leq .05$) from 0.12 to 3.1 X 10^4 cfu/g. This higher bacterial count could be due to the adverse conditions of storage environment (temperature and relative humidity), which facilities the rapid entry of moisture inside the Avocado milk shake powder sample and subsequently enhances the bacterial count of the product.

(Barooah *et al.,* 2018) Similar to the results of the bacterial count, the fungal count of the banana milk shake powder samples also increased significantly from third month of the storage period. 0 days of preparation at an interval of 30 days the findings of the study revealed significant increase in the microbial load in banana milk shake powder from 30 days of storage at 5% probability level up to 90 days. At 0 days the cfu count depicted non-significant

Table 3: Effect of packaging material and storage days on sensory characteristics of spray dried avocado milk shake powder

Packaging material	*Storage days*	*Color*	*Appearance*	*Consistency*	*Flavour*	*Mouth feel*	*OA*
Metalized polyester film	0	8.02	8.55	7.68	7.45	7.51	8.02
	15	7.90	8.10	7.30	7.2	7.30	7.70
	30	7.70	7.70	7.10	7.00	7.40	7.68
	45	7.50	7.50	7.00	6.70	7.10	7.01
	60	7.00	7.10	6.80	6.40	6.90	7.00
	75	6.80	6.90	6.60	6.80	6.50	6.56
	90	6.70	6.60	6.20	6.20	6.40	6.44
	CD @ 5%	0.895	0.912	0.821	0.862	0.876	0.947
	Sem ±	0.294	0.315	0.264	0.213	0.281	0.304

Table 4: Effect of storage on microbial load of spray dried avocado milk shake powder sample stored in metalized polyester (MP) film

Storage period (days)	*Total plate count (10^4 CFU/g)*	*Yeast and molds (10^0 CFU/g)*	*Coliforms (10^0CFU/g)*
0	0.12	Nil	Nil
15	0.14	Nil	Nil
30	0.21	Nil	Nil
45	0.25	Nil	Nil
60	0.29	Nil	Nil
75	2.9	1.2	Nil
90	1.3	2.3	Nil
SEm (±)	0.155	0.238	-
CD @ 5 %	0.056	0.058	-

increase in the packaging materials. At 30 days, microbial load was found to increase significantly (F=4.7931) from 0 to 0.40×10^{-6} cfu/ mL.

(Priyanka *et al.,* 2018) reported in Mango milkshake powder no visible microbial growth was seen till 30th day of storage followed by an increasing trend in the microbial growth from 60th to 90th day of storage. Maximum microbial growth noticed was 3.45±.06 log10 cfu/mL which was well within permissible limits as given by FSSAI (2011).

CONCULSION

Avocado is seasonal fruit which can be preserved through spray dryer by converting the milk shake in to powder by analyzing the physico chemical parameters on process parameters of spray dryer that is Inlet temperature, feed flow rate and total solids. Result of optimization study showed that at the optimum point, process parameters can be used to obtain avocado milk shake powder with quality properties like spray dried powder. Inlet temperature showed significant effect on all responses. Increasing inlet temperature led to lower moisture content, water activity, bulk density and pH, effect of feed flow rate and total solids on some responses was found statistically significant. Thus, the optimized product were obtained through analyzing by RSM method (Design Expert- 12.0.3.0) .The optimized condition was obtained at 19 % total solids, feed flow rate 11rpm and 150°C inlet air temperature. The predicted moisture content, bulk density, water activity, pH, color values (*L*, a** and *b**), overall acceptability, loose bulk density and tapped bulk density value were proven to be 4.30 per cent, 0.22, 6.31, 91.99, -0.523, 11.65, 8.92, 0.369 g/cc and 0.526 g/cc, respectively and The powder was stored in Metalized polyester pouch under ambient conditions for 3 months and the physico-chemical properties, sensory and microbial analysis were studied for every 15 days if interval. It was observed that the quality of the powder had not deteriorated during the storage period of 90 days.

References

ANANDHARAMAKRISHNAN, C., RIELLY, C.D. AND STAPLEY, A.G.F., 2007, Effects of process variables on the denaturation of whey proteins during spray drying. *Dry. Technol*., **25** (5):799-87.

AOAC, 2000, Official Methods of Analysis, 18th edn, Association of Official Analytical Chemists, Gaithersburg, MD, USA

ARAB, A. A., SALEM, A. F. M. AND ARAB, E. A., 2011, Physico-chemical properties of atural pigments (*anthocyanin*) extracted from Roselle calyces (*Hibiscus subdariffa*). *J. Am. Sci.*, **7** (7):445-456.

BIRCHAL, V.S., PASSOS, M.L., WILDHAGEN, G.R. & MUJUMDAR, A.S. 2005, Effect of spray-dryer operating variables on the whole milk powder quality. *Drying Technology*., **23**(3): 611–636

CAPARINO, O. A., TANG, J., NINDO, C. I., SABLANI, S. S., POWERS, J. R. AND FELLMAN, J. K., 2012, Effect of drying methods on the physical properties and microstructures of mango (*Philippine Carabao* var.) powder. *J. Food Eng.*, **111** (1): 135-148.

CORNELL, J. A. 1990, How to apply response surface methodology:(Vol 8) American Society for Quality Control Statistics Division.

DANTAS, D., PASQUALI, M.A., CAVALCANTI-MATA, M., DUARTE, M.E. AND LISBOA, H.M., 2018, Influence of spray drying conditions on the properties of avocado powder drink. *Food chemistry*., **266:** 284-291.

FAVIER, J.C., IRELAND-RIPERT, J., TOQUE, C., FEINBERG, M. AND FAVANO, A., 1999, Repertório geral dos alimentos: tabela de composição. In Repertório geral dos alimentos: tabela de composição: 895-895.

ORHEVBA, B.A. AND JINADU, A.O., 2011, Determination of physico-chemical properties and nutritional contents of avocado pear (*Persea americana* M.). Proc. 11th Intl. Conf., *Nigerian Institution of Agricultural Engineers* (NIAE).

PANDEY, S., APARNA, K., CHAUHAN, A.K. AND SINGH, M., 2020, Development of phytonutrient enriched avocado milkshake powder and its quality evaluation. *Indian J Dairy Sci.*, **73** (6) : 1-7.

PHISUT, N., 2012, Spray drying technique of fruit juice powder: some factors influencing the properties of product. Int. Food Res. J., 19(4): 1297-1306

VENNILA, P., KENNEDY, Z.J., PREETHA, P. AND PANDIDURAI, G., 2020, Studies on formulation and evaluation of muskmelon fruit powder incorporated ready-to-useproducts. *Journal of Pharmacognosy and Phytochemistry*., **9**(3): 1768-17.