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Optimization of Spray Drying Condition for Production of Aloe Vera and Sugarcane Juice Flavoured With Cocoa

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ABSTRACT
The aim of this work was to optimize the spray drying condition for the production of aloe-vera and sugarcane juice powder. A model glass spray dryer was utilised for the operation; maltodextrin was employed as stabilizer, cocoa for natural flavouring and sugarcane added to aloe vera juice. Response Surface Methodology (RSM) was performed to analyse the inlet air temperature(180, 190 and 200°C) and maltodextrin concentration (12 ,15 and 20%) with a feed flow rate of (3 ,4 and 6ml/min) on yield, moisture content, solubility, bulk density, vitamin C and antioxidant for the reconstituted powder. The following optimum process conditions were determined: inlet air temperature of 196.5°C, maltodextrin concentration of 20% and feed flow rate of 6ml/min. The optimum conditions, powder recovery, moisture content, solubility, vitamin C, antioxidant, bulk density, pH, TSS, titratable acidity were determined to be 13.64%, 5.63%, 183.369sec, 0.059mg/ml, 0.0572mg/ml, 0.420 mg/ml, 7.50, 22.6%, 0.70 respectively.

Keywords: Aloe vera, sugarcane, Maltodextrin, cocoa, Response Surface Methodology, spray drying.

INTRODUCTION
Aloe Vera (Scientific name *Aloe barbadenis* Mill., family Liliaceae), also known as Barbados or Curacao aloe, has been used in traditional and folk medicines for thousands of years to treat and cure a variety of diseases. A variety of aloe species are used in folk medicines of Africa and Asia. Aloe Vera is a succulent plant with thick, fleshy, serrated, lanceolate shaped leaves of green color. Aloe Vera inner gel is obtained from the lower leaves of the plant by slicing the leaf open. The gel is clear, odourless and tasteless and should be free of leaf skin or yellow parts. Aloe Vera has long been enchaining the human beings because of its graceful appearance, adaptable nature and most importantly the medical benefits associated with aloe Vera. Unlike many other types of plants, the aloe Vera does not required too much of water, or very specific conditions to grow. **(Rodriguez S, 2008).**Aloe vera contains 75 potentially active constituents: vitamins, enzymes, minerals, sugars, lignin, saponins, salicylic acids and amino acids. Aloe vera has been most commonly used for the treatment of burn wounds and healing process, reduce inflammation and tissue scaring. The gel was used to treat wounds and mouth infections, soothe itching and cure sores. It also act as antiviral and antitumor agent(**Preetinder Kaur*et al.*,2019**).Sugarcane (Saccharum officinarum), is a species of the tall perennial true grass and belongs to the grass family Poaceae. Sugarcane is one of the valuable crops grown in the world. Sugarcane grows in a variety of soils, but it grows best in deep, well drained soil that is rich in organic matter with a pH of between 5.0 and 8.0. **(Yadav&Solomon *et al.*, 2006**).Fresh sugarcane juice contains phosphorous, potassium, calcium, iron and maganesium as well as vitamins A,B1,B2,B3,B5,B6, C and E Food Chemistry published a study in March 2014 investigating the antioxidant and phenolic

composition of sugarcane. The juice contains phenolic acids and protective compounds such as quercetin, caffeic acid and ellagic acid **(Singh *et al.*, 2015**).
Quercetin, is an antioxidant that has anti-inflammatory and anti-carcinogenic properties. Caffeic acid is an important antioxidant that can protect against the DNA damage caused by free radicals and in your diet that cause cell destruction and mutation. Sugarcane benefits include anti-hyperglycemic, analgesic, diuretic and hepatoprotective (liver protecting) effects **(GuptaM, *et al.*,*2006*)**.Spray drying is a method of producing a dry powder from a liquid or slurry by rapidly drying with a hot air. This is the preferred method of drying of many thermally sensitive materials such as foods and pharmaceuticals. All spray drier use some type of atomizer or spray nozzle to disperse the liquid or slurry into a controlled drop size spray. The most common of these are rotary disk and single fluid high pressure swirl nozzles. The temperature ranges from 180 to 220 degree celcius depending on the nature of the feed. The most commonly used drier are single effect drier as it contains single source of drying chamber at the top **(M.C. Gohel, 2005).**The values are being studied with the help of RSM (Response Surface Methodology). The RSM is a widely used mathematical and statistical method for modelling and analysing a process in which the response of interest is affected by various variables. The objective of this method is to optimise the response.Where the dependent and independent variables are fed in the RSM and the experimental design is obtained. Number of trial are done to obtain optimised product **(Youssefi *et al.*, 2009).**Since there is more medicinal and nutritive value in the Aloe vera and sugar cane juice we are incorporating both in liquid form and bought to powder. The reason to choose powder form because there is more availability of the raw material and cannot be used directly of the bitter taste of aloe vera, combining it with sugarcane juice as a sweetener. The target group of people is children and this can be used as substituent of food or health drink.

MATERIALS AND METHODS

Experimental site

The experimental was conducted in the Kalasalingam Academy Of Research and Education, Krishnan koil, Tamil nadu.

Sample Preparation

Aloe vera were collected from nearby village and sugarcane were obtained from the fruit vendor, Madurai. Aloe vera were washed with water and cut the both ends of aloe vera . The aloe vera gel were homogenised in a mixer grinder, filtered through a muslin cloth to get fine juice. Sugar cane juice was added to a aloe vera juice and then cocoa powder was added to a small amount of the juice. Maltodextrin were added to a juice and kept in magnetic stirrer at 1500rpm for 10mins to get uniform slurry.

Spray Drying Process

The spray drying was performed in Technosearch Instruments. The spray drying was carried out using concurrent system. The slurry was kept was using a magnetic stirrer and stirred at low speed while fed into the spray dryer. The inner diameter of atomizer nozzle was 1.0 mm and the feed flow rate was controlled by the pump rotation speed. The operational conditions for the drying process were inlet air temperature and feed flow rate ranging between 180–200 °C and 3–6 ml/min respectively. The concentration of MD (DE 10) was varied between 12% and 20% for successful spray drying. The samples were weighed, packaged using zip lock cover and then stored at optimum temperature for future analysis.

pH

pH of the aloe vera sugarcane extract were determined by using a pH meter. 10ml of sample was taken in a beaker and probe of the pH meter was dipped into the sample for a few seconds. The pH value of the sample will be displayed.(Sangeetha Saikia *et al* 2014).

Total Soluable Solids

TSS of the samples were determined by using a hand refractometer. One or two drops of juice were put on the sample plate and the reading was recorded.(Sangeetha Saikia *et al* 2014).

Titrable Acidity

Titrable acidity of the sample were determined by titrating the sample against 0.1N NaOH by using Phenolphthalein as a indicator. Appearance of pink colour determines the end point(Vishal Namdeo Sabhadinde, 2014)

Bulk Density

Bulk density is a property of granules and powder It is referred to as the mass of various particles of materials divided by total volume occupied them. The density was calculated by mass per volume.((Sonika Pandey *et al* 2019)

Bulk density= mass of the sample /bulk volume

Moisture Content

Two gram sample was measured and dried in a hot air oven at 105°C until constant weight was obtained and the analysis was performed. The final moisture content percentage were calculated by ratio of the initial weight subtracted to final weight to the weight of powder sample multiplied by 100.(Preetinder Kaur *et al* 2017)

Moisture content (%)= initial weight of sample- final weight of sample/ initial weight of the powder*100

Solubility

The solubility was determined according to the method described by Chau et al. (2007). Powder sample was mixed with distilled water (1:10 w/v) and stirred for 1 h at room temperature and centrifuged at 1,500 rpm for 10 min. The supernatant was collected, dried and weighed. The solubility is calculated as given in equation.

Solubility %=weight (g) of the supernatant collected after drying / weight (g) of the powder sample *100

Vitamin C

The sample was taken and equilibrated with 150 ml distilled water separately into distinct conical flask 250.00 ml and titrant containing iodine solution was run against analyte containing either sample or standard; 5-6 drops of prepared starch solution were added to the analyte and titration was started. The endpoint was noted when analyte appears blue in color. (Sonika Pandey *et al* 2019)

Vitamin c= end point* 0.005N

Antioxidant

A solution of hydrogen peroxide was perpetrated in phosphate buffer(Ph 7.4). A Sample of 1g diluted with distilled water and extracted sample (100 µg/mL) in distilled water were added to a hydrogen peroxide solution (0.6 mL, 40mM). Absorbance of hydrogen peroxide at 230nm was determined 10 minutes later against a blank solution containing the phosphate buffer without hydrogen peroxide. The percentage of hydrogen peroxide scavenging of sample and standard compound were calculated as

% Scavenged (H_2O_2) =(A_c-A_s)/A_S*100

Where A_C is the absorbance of the control and A_C is the absorbance in the presence of the sample of powder.

Experimental Design and Statistical RSM

Response surface methodology (RSM) was used to derive the optimum formulation conditions . A central composite design was applied forthree independent variables. RSM is a novel arithmetical design employed to evaluate problems wherein the response is dependent on several independent variables with an objective to maximize the process variables for achieving optimum response The independent variables of different levels of inlet air temperature(A), feed flow rate(B)and maltodextrin concentration (C), affected the quality of the end product. Table 1 shows the coded and actual level of experimental design. The regression equation coefficients were calculated and the data were fitted to a second order polynomial equation The adequacy of model was evaluated by coefficient of determination (R2) and model P value. The analysis of variance (ANOVA) of various responses for lipid productivity (dcw %), biomass (gL-1) by using RSM (Singh et al., 2013).

Table1 Experimental design for spray drying runs and independent variables on their corresponding response value

			Factor 1	Factor 2	Factor 3	Response 1	Response 2	Response 3	Response 4	Response 5	Response 6
Std	Run	Block	A:inlet air temperature	B:feed flow rate	C:maltodextrin concentration	yield	moisture content	solubility	bulk density	vitaminc	antioxidant
			°C	ml/min	%	%	%	sec	mg/ml	mg/ml	mg/ml
1	1	Block 1	180	3	12	12.62	6	169	0.481	0.0325	0.022
4	2	Block 1	200	6	12	5.2	7	175	0.414	0.031	0.062
3	3	Block 1	180	6	12	2.04	5	174	0.012	0.0225	0.063
14	4	Block 1	190	4.5	22.72717	11.005	5.5	164	0.478	0.04	0.047
2	5	Block 1	200	3	12	10.87	3	180	0.324	0.0405	0.048
11	6	Block 1	190	1.977311	16	8.3	4	171	0.398	0.0325	0.036
10	7	Block 1	206.8179	4.5	16	10.93	6	169	0.314	0.03	0.46
5	8	Block 1	180	3	20	14.15	8	154	0.333	0.004	0.055
16	9	Block 1	190	4.5	16	15.12	8	184	0.356	0.404	0
7	10	Block 1	180	6	20	11.64	7.5	170	0.412	0.035	0.033
18	11	Block 1	190	4.5	16	17.25	5	190	0.332	0.045	0.058
12	12	Block 1	190	7.022689	16	4.78	6.75	175	0.201	0.0365	0.021
6	13	Block 1	200	3	20	14	5	156	0.329	0.03	0.052
8	14	Block 1	200	6	20	14.37	6	190	0.405	0.03	0.044
13	15	Block 1	190	4.5	9.272829	4.9	6.5	170	0.212	0.0325	0.023
19	16	Block 1	190	4.5	16	16.12	2.5	160	0.356	0.045	0.048
17	17	Block 1	190	4.5	16	17.25	2.6	190	0.375	0.0405	0.345
15	18	Block 1	190	4.5	16	8.94	5.5	187	0.312	0.03	0.075
9	19	Block 1	173.1821	4.5	16	10.62	7	165	0.363	0.035	0.031
20	20	Block 1	190	4.5	16	16.25	5.6	180	0.381	0.041	0.032

RESULTS AND DISCUSSION

Sugarcane and Aloe-Vera Juice

The sugarcane and the aloe-vera juice was prepared in the ratio of 50:50, and the flavouring agent Cocoa powder 0.5% was added and the carrier agent, Malto-Dextrin was added to get maximized yeild of 15.24%. The physciochemical characteristics of the juice like pH, TSS, Titrable acidity was studied and the values were given in Table2.

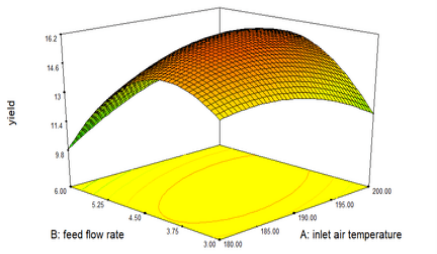
Table.2 Physiochemical Characteristics

S.No	Characteristics	Values
1	Ph	7.50
2	TSS	22.6%
3	Titrable Acidity	0.70

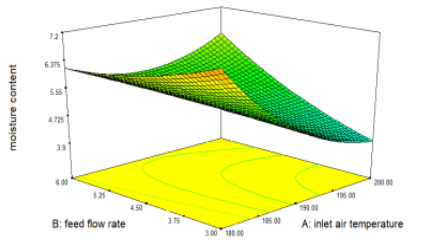
Effect of mutual optimized process variables

The test statistic for lack-of-fit is the ratio between the lack-of-fit mean square and the pure error mean square (Singh et al.,2013; Kirrolia et al.,2014). Lack of fit, non significant value has shown the validity of the quadratic model for various responses of the experimental culture. F-test statistic used in order to determine lack of fit error whether it is significant or not . Signal to noise ratio was measured by adequate precision. Signal to noise ratio greater than 4 is suitable for model validation. Three dimensional (3D) graphs were used to explore the sensitivity of the responses of two interacting variables by holding the other variables constant at central values (Kirrolia et al., 2013).

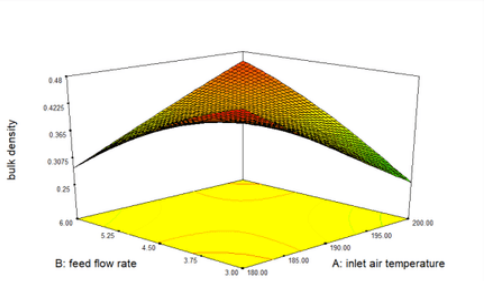
The Graphical representation of outcomes of the product such as Yeild, Moisture content, Solubility, Bulk Density, Vitamin C, Anti-Oxidants are given below as Figure 1,2,3,4,5,6.



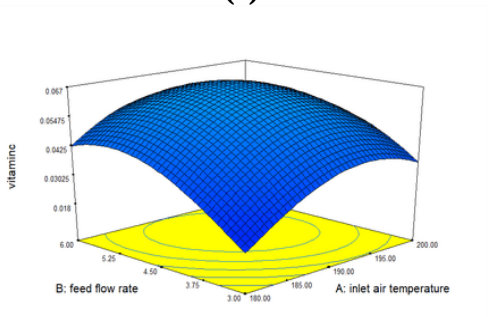
(a)



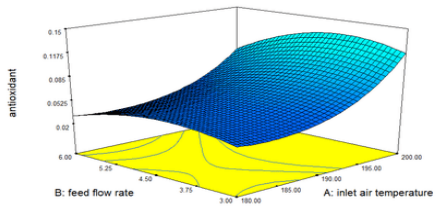
(b)



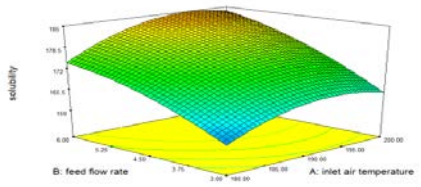
(c)



(d)



(e)



(f)

Figure 2: Three dimensional response surface plots showing mutual interaction between inlet air temp and feed flow rate on a: yield,b: moisture content, c: bulk density, d: vitamin, e: antioxidants, f: solubility of the powder

From the study it reveals that when the interaction terms of inlet air temperature and feed flow rate is positive the yield is higher. When the quadratic terms of each individual variable the yield percentage is minimum. In case of solubility the powder has to dissolve in minimum time. When the variables are found to be interactive the solubility ration was decrease it means higher the interaction variable the solubility time taken for the aloe vera powder was less. The nutritional properties such as antioxidant and vitamin c were increased in the both quadratic and interaction terms of the variables. Higher the maltodextrin and lower the inlet temperature the vitamin c content was present above average value.

Spray-dried sugarcane and aloe vera powder

In spray drying process of Sugaracane and Aloe-Vera juice flavoured with Cocoa powder with 20% of maltodextrin and the temperature of 196.5°C and the feed flow rate of 6ml/min,

the powder obtained was found to be better in nature. The colour of the powder was found to be brownish white in nature and the picture was given below as Figure .3

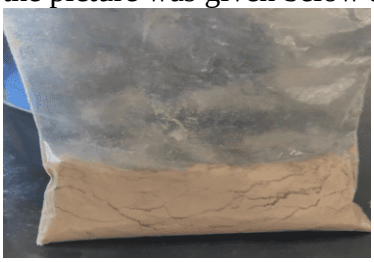


Figure 3. Sugarcane and Aloe-Vera Powder

The outcomes of the product such as yeid, moisture content, solublity, bulk density, Vitamin C and anti-oxidant were analysed

Table.3 Product Outcomes

S.No	Parameters	Values
1	Yield	15.24%
2	Moisture Content	5.34%
3	Solubility	181.96 sec
4	Bulk Density	0.41mg/ ml
5	Vitamin C	0.059mg /ml
6	Anti-Oxidants	0.089mg /ml

CONCLUSION

In this study, experiments to prepare aloe-vera sugarcane powder were conducted using spray drying technique. The effects of inlet air temperature, feed flow rate and maltodextrin concentration on physico-chemical properties of aloe-vera powder were studied. The optimum results indicated that an inlet air temperature of 196.5°C, maltodextrin concentration of 20% and feed flow rate of 6ml/min will produce powder with the best properties. At these optimum conditions, powder recovery, moisture content, solubility, vitamin C, antioxidant, bulk density, pH, TSS, titratable acidity were determined to be 13.64%, 5.63%, 183.369sec, 0.059mg/ml, 0.0572mg/ml, 0.420 mg/ml, 7.50, 22.6%, 0.70 respectively

Conflict of interest : The authors disclosed that there was no conflicts of interest

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