International Journal of Food, Agriculture and Veterinary Sciences ISSN: 2277-209X (Online)
An Online International Journal Available at http://www.cibtech.org/jfav.htm
2012 Vol. 2 (2) April-June, pp. 67-73/Khan Chand and Pandey
Research Article

OPTIMIZATION OF FOAM MAT DRYING PROCESS VARIABLES FOR MALTA POWDER

***Khan Chand and R.K. Pandey**
Department of Process and Food Engineering, College of Technology,
G.B. Pant University of Agriculture & Technology, Pantnagar,
Udham Singh Nagar 263 145, Uttarakhand, India
**Author for Correspondence*

ABSTRACT
Vacuum drying of malta juice concentrate was carried out at various levels of carboxy methyl cellulose (CMC) ranging between 0.08 and 0.016 kg per kg of malta solid. Glycerol monostearate (GMS), whole milk powder (WMP) and tricalcium phosphate (TCP) were added at the levels varying between 0.005 to 0.015, 0.02 to 0.06 and 0.0025 to 0.0045 kg per kg of malta solid, respectively. CMC was used to eliminate the stickiness of the malta powder and to get less hygroscopic powder. GMS was used as foam stabilizer, whole milk powder used to improve nutritional quality of powder and TCP as anticaking agents respectively. Hygroscopicity, degree of caking, flowability time and solubility of dried powder at 5% (db) moisture content were determined. Based on these properties of malta powder, Optimum level of ingredients obtained by using simultaneous optimization of flowability time, degree of caking and solubility were: 7.92% carboxy methyl cellulose, 85°C temperature, 1.55% whole milk powder, 0.225% tricalcium phosphate and 0.271% glycerol monostearate.

Kew Words: *Malta Juice Concentrate, Carboxy Methyl Cellulose, Whole Milk Powder, Tricalcium Phosphate and Glycerol Monostearate.*

INTRODUCTION

Citrus fruits occupy a predominant place in the fruit industry of Uttarakhand state. Total production of citrus fruits in Uttrakhand is 723.6 thousand metric tone in area of 193.8 thousand hectare in 2009-2010 (NHB) out of which sharing about 14.38 percent of the total area under fruits and contributing about 17.75 percent to the total fruit production (Anonymous, 2006). The most important commercial citrus cultivar is sweet orange. Among these cultivars “malta Common” is grown on a large scale in Punjab, Haryana, Uttarakhand and Western district of Uttar Pradesh. “Malta Common” one of the most important cultivar of citrus fruit, is grown in most of the hilly districts of the state Uttrakhand like Ghat, Mandal, Nagnath, Pakhari area of district Chamoli, Quiti, Thal, Berinag, Didihat of district Pithoragarh, and some areas of district Rudraprayag. The high acceptability of “Malta Common” is due to its attractive colour, distinctive flavor and taste. The excellent quality fruits are generally available for only one or two months. However owing to its poor shelf-life, fruits cannot be stored for longer period under ambient conditions and cannot be transported to distant places. By and large, this fruit is harvested by shaking the tree or manually twisting and plucking. Citrus fruits are non climacteric in nature and their eating quality cannot be improved after harvest. So it is necessary to harvest the fruits properly so that quality of fruit is at their best (Fuchs and Barki-Golan, 1979).Vacuum drying has been successfully applied to many fruits and vegetables and other heat sensitive foods. In this method since, the drying takes place in the absence of oxygen, the oxidative degradation e.g. browning is low in the final product. The rate of drying is fast due to the creation of frothy or puffed structure in the juice concentrate (Jaya and Das, 2004). Vacuum dried materials are characterized by better quality retention of nutrients and volatile aroma. However, the cost of the process is high (Tsami *et al.*, 1999). In view of the above, present study was undertaken with the following objective: To study the effect of Carboxy methyl cellulose, tricalcium phosphate, glycerol monosterate, skim milk powder and drying temperature of concentrated malta juice.

MATERIALS AND METHODS

Materials

Fresh, well graded, good quality fully ripe Malta (sweet orange) of variety *Valencia* were procured from the Haldwani Sabji Mandi, Distt. Nainital, Uttrakhand.

Experimental Design

Response surface methodology (RSM) was adopted in experimental design. The variables parameters namely temperature, carboxy methyl cellulose, tricalcium phosphate, glycerol, monosterate and whole milk powder were selected. A second order central composite rotatable design (CCRD) was used to determine the number of experiments at five levels. Experiments also carried out at centre point. The number of design points in (CCRD) is based upon a half fraction of 2^k factorial design (Khuri and Cornell, 1987).

The total numbers of experiments are,

$$N= 2^{K-1}+2K+L \qquad \ldots(3.1)$$

where,

N= Total Number of experiments

K= Numbers of Factors

L= number of replicates of the central point

Sample Preparation

The malta fruits were sorted and the fleshy portion of malta were separated manually with the help of stainless steel knife and the juice was extracted using juicer machine (Modern Scientific Sales Corporation Delhi, Model No. 626C). The malta juice was concentrated upto 40 ° Brix using vacuum rotary evaporator (JSGW) at 80 ^{0}C for 4 hrs at constant speed of variac (15m/s) (Akhtar *et al.*, 2010). The malta concentrate juice was kept in containers and stored under refrigerated conditions (5 ^{0}C) till further use.

Selection of Additives for the Malta Powder Preparation

During the preliminary trials, the malta concentrate was subjected to drying without any addition of drying aids, viz. anticaking and antioxidative agents. It was noticed that the final product showed a significant colour change with respect to browning and stickiness. The final product resulted into sheet and it was difficult to remove this sheet manually from Petri dishes. Therefore, prior to start the experiments some additives, drying aids, stabilizers and anticaking were added into malta concentrate.

Vacuum Drying For the Preparation of Malta Powder

The malta concentrate mixture was dried in a laboratory model vacuum oven (MSW-218).The mixture after suitable addition of drying aids was spread evenly into petri dishes, having diameter of 15 cm. The petri dishes were then placed on the shelves of the vacuum oven and the pressure was reduced until the vacuum inside the chamber reached to 25″ Hg. Five different drying temperatures (65, 70, 75, 80, 85 °C) and drying time (0, 20, 140, 260, 380, 500 and 600 minutes) were selected to carry out vacuum drying.The drying behavior was studied in terms of moisture content (% db) with respect to time and temperature. The dried malta concentrate was powdered into a fine particulate powder using a food processor at medium speed for 5min. The prepared malta powder from the vacuum drying method was analyzed for phsico-chemical characteristics viz. hygroscopicity (%), flowability time (s), degree of caking (%) and solubility (%).

Analytical Methods

Flowability Time

Flowability time of malta powder was determined byflowability measurement apparatus (Jaya and Das, 2006).

Hygroscopicity

Hygroscopicity is expressed as the final moisture content attained after exposing the powder in humid air having 85.11% relative humidity. The hygroscopicity of the powder was calculated using the relation given in Eq. 3.2. Generally, a powder having the hygroscopicity value less than 10 % is considered as good 'non hygroscopic' powder.

$$HG = \frac{\frac{b}{a} + W}{1 + \frac{b}{a}} \qquad \ldots 3.2$$

where, b (g) is the increase in weight of powder, a (g) is the amount of powder taken for the measurement and W (% wb) is the free water present in the powder before allowing it in to the humid air environment (Jaya and Das, 2006).

Degree of Caking

After the determination of hygroscopicity, the wet sample obtained at the end of hygroscopicity measurement was placed along with the Gooch filter in a drying oven set at 102$\pm$2 ^{0}C for one hour to measure degree of caking. After cooling the dried sample, it was weighed and transferred into a sieve of 500 µm size. The sieve was then vibrated for 5 min in a shaking apparatus. The weight of the powder remaining in the sieve was measured. Degree of caking, DC (%) was calculated by using following equation:

$$DC = \frac{c}{d} x100 \qquad \ldots (3.3)$$

Where, d (g) is amount of the powder used for sieving and c (g) is amount of the powder left on the sieving after sieving. Normally, the degree of caking between 5 to 20% is called as 'slightly caking' powder (Jaya and Das, 2006).

Solubility

For the determination of solubility, 100 ml of distilled water was transferred into blender jar. The powder sample (1g, dry basis) was carefully added into the blender operating at high velocity for 5 min. The solution was placed in tube and centrifuged at 3000 rpm for 5 min. An aliquot of 25 ml of the supernatant was transferred to preweighed petri dishes and immediately oven-dried at 105 ^{o}C for 5 h. Then the solubility (%) was calculated by weight difference (Chauca *et al.*, 2005).

RESULTS AND DISCUSSION

Quality characteristics of vacuum dried malta powder were determined in terms of flowability time, degree of caking, solubility, hygroscopicity and colour. Chemical analysis of malta powder was carried out to investigate the effect of drying condition and added ingredients on nutritional quality of malta powder. Colour of sample was determined using the digital camera and Adobe Photoshop 7.0.Optimization of added ingredients and temperature based on the powder properties was done using Design –Expert 8.0.1.7 software.

Effect Of Drying Temperature And Ingredients On Quality Parameters Of Malta Powder

The flowability time of powder varied from 13.4 to 19.8 s. It was minimum at experiment number 12 (7% carboxy methyl cellulose, 80 °C temperature, 1.5% whole milk powder, 0.2% tricalcium phosphate and 0.375% glycerol monostearate). Hygroscopicity was in the range of 1.45 (Expt No. 13) to 6.38 (Expt No. 6) while the degree of caking is in between 2.04 (Expt No. 13) to 4.25% (Expt No. 3). Minimum solubility of malta powder was about 72.7 (Expt No. 1) and it increased upto 91.1 % (Expt No. 16).

Effect of Variables On Flowability Time

Model was highly significant (P<0.01) with F-value as 5.29. Therefore, second order model was adequate in describing flowability time. Effect of ingredients at linear, quadratic and interactive levels is reported in Table 1. It shows that the effect at linear, quadratic and interactive levels were highly significant (P<0.01). Total effect of individual parameter on flowability time was calculated using the sequential sum of squares, and it is given in the Table 2. It was observed that methyl cellulose, temperature, whole milk powder, tricalcium phosphate and glycerol monostearate affected the flowability time significantly at 1% level of significance. Effect of temperature was found highest as compared to that of other variable parameters. Similar results were obtained by Jaya and Das (2004).

Table 1 ANOVA for flowability time

SOURCE	DF	SS	MS	F-Value
Model	20	94.79	4.74	5.29*
Linear	5	39.87	39.87	44.5*
Quadratic	5	23.66	23.66	26.41*
Interactive	10	35.42	35.42	39.53*
Error	11	9.86	0.9	
Total	31	104.65		

**, ** Significant at 1, 5% level of significance respectively*
F_{tab} = (Model-4.10 (1%) & 2.65 (5%)) (Linear & Quadratic level- 5.32(1%) & 3.20 (5%)) (Interactive level – 4.54(1%) & 2.85(5%))

Table 2 Total effect of individual parameters on flowability time

Source	DF	SS	MS	F-Value
Model	20	94.79	4.74	5.29*
Carboxy Methyl Cellulose (X_1)	6	13.57	13.57	15.14*
Temperature (X_2)	6	41.98	41.98	46.84*
Whole Milk Powder (X_3)	6	30.50	30.5	34.03*
Tricalcium Phosphate (X_4)	6	22.80	22.8	25.45*
Glycerol Monostearate (X_5)	6	25.55	25.55	28.51*
Error	11	9.86	0.9	
Total	31	104.65		

**, ** significant at 1, 5% level of significance respectively*
$F_{(20,11,0.01)}$ =4.10 and F_{tab} = 3.09 (5%) & 5.07 (1%)

Effect of Variables on Degree of Caking

The model was significant at P<0.05. The model was considered adequate as it had a high R^2 and F-value. Effect of ingredients at linear, quadratic and interactive levels is reported in Table 3. It shows that the effect at interactive level was highly significant (P<0.01). Model was significant at 5% level of significance, while linear and quadratic levels were significant at 1 % (P<0.01). Total effect of individual parameter on degree of caking was calculated using the sequential sum of squares, and it is given in the Table 4. It was observed that all the variable parameters affected the degree of caking significantly at 1% level of significance. Carboxy methyl cellulose had highest effect on degree of caking (P<0.01). Similar results reported by Jaya and Das (2004).

Effect of Variables on Solubility

The model was considered inadequate as it had a low R^2 value and non significant F value (P>0.05) Effect of ingredients at linear, quadratic and interactive levels is reported in Table 5. It shows that the effect at linear and interactive level was significant at 1% level of significance, but that at quadratic level was not significant. Total effect of individual parameter on solubility is given in Table 6. It was observed that glycerol monostearate and temperature affected the solubility significantly at 1% level of significance.

Table 3: ANOVA for degree of caking

SOURCE	DF	SS	MS	F-Value
Model	20	7.36	0.37	4.03**
Linear	5	2.56	2.56	27.99*
Quadratic	5	0.529	0.53	5.78*
Interactive	10	4.36	4.36	47.73*
Error	11	1.01	0.091	
Total	**31**	**8.37**		

**, ** Significant at 1, 5% level of significance respectively*
F_{tab} = (Model-4.10 (1%) & 2.65 (5%)) (Linear & Quadratic level- 5.32(1%) & 3.20 (5%)) (Interactive level – 4.54(1%) & 2.85(5%))

Table 4: Total effect of individual parameters on Degree of caking

Source	DF	SS	MS	F-Value
Model	20	7.36	0.37	4.03**
Carboxy Methyl Cellulose (X_1)	6	3.58	3.58	39.19*
Temperature (X_2)	6	2.77	2.77	30.4*
Whole Milk Powder (X_3)	6	0.93	0.93	10.22*
Tricalcium Phosphate (X_4)	6	3.45	3.45	37.8*
Glycerol Monostearate (X_5)	6	1.06	1.06	11.61*
Error	11	1.01	0.091	
Total	31	8.37		

**, ** significant at 1, 5% level of significance respectively*
$F_{(20,11,0.01)}$ =4.10 and F_{tab} = 3.09 (5%) & 5.07 (1%)

Table 5: ANOVA for Solubility

SOURCE	DF	SS	MS	F-Value
Model	20	594.81	29.74	1.06
Linear	5	299.96	299.96	10.725*
Quadratic	5	141.24	141.24	5.05**
Interactive	10	157.11	157.11	5.62*
Error	11	307.67	27.97	
Total	31	902.48		

**, ** Significant at 1, 5% level of significance respectively*
F_{tab} = (Model-4.10 (1%) & 2.65 (5%)) (Linear & Quadratic level- 5.32(1%) & 3.20 (5%)) (Interactive level – 4.54(1%) & 2.85(5%))

Table 6: Total effect of individual parameters on Solubility

Source	DF	SS	MS	F-Value
Model	20	594.81	29.74	1.06
Carboxy Methyl Cellulose (X_1)	6	23.73	23.73	0.854
Temperature (X_2)	6	438.34	438.34	15.67*
Whole Milk Powder (X_3)	6	63.47	63.47	2.28
Tricalcium Phosphate (X_4)	6	39.85	39.85	1.424
Glycerol Monostearate (X_5)	6	190.10	190.1	6.79*
Error	11	307.67	27.97	
Total	31	902.48		

**, ** significant at 1, 5% level of significance respectively*
$F_{(20,11,0.01)}$ =4.10 and F_{tab} = 3.09 (5%) & 5.07 (1%)

Effect of variables on hygroscopicity

The model was considered adequate for describing the hygroscopicity due to higher value of R^2 and F in Table 7. Total effect of individual parameter on hygroscopicity is given in Table 8**.** It was observed that carboxy methyl cellulose, Temperature, whole milk powder, tricalcium phosphate and glycerol monostearate affected the hygroscopicity significantly at 1% level of significance.

Table 7: ANOVA for Hygroscopicity

SOURCE	DF	SS	MS	F-Value
Model	20	32.23	1.61	5.19*
Linear	5	12.92	12.92	41.66*
Quadratic	5	6.99	6.99	22.54*
Interactive	10	12.21	12.21	39.36*
Error	11	3.41	0.31	
Total	31	35.64		

**, ** Significant at 1, 5% level of significance respectively*
F_{tab} = (Model-4.10 (1%) & 2.65 (5%)) (Linear & Quadratic level- 5.32(1%) & 3.20 (5%)) (Interactive level – 4.54(1%) & 2.85(5%))

Table 8: Total Effect Of Individual Parameters On Hygroscopicity

Source	DF	SS	MS	F-Value
Model	20	32.23	1.61	5.19*
Carboxy Methyl Cellulose (X_1)	6	13.03	13.03	41.99*
Temperature (X_2)	6	9.97	9.97	32.11*
Whole Milk Powder (X_3)	6	3.57	3.57	11.49*
Tricalcium Phosphate (X_4)	6	6.86	6.86	22.12*
Glycerol Monostearate (X_5)	6	10.93	10.93	35.2*
Error	11	3.41	0.31	
Total	31	35.64		

**, ** significant at 1, 5% level of significance respectively*
$F_{(20,11,0.01)}$ =4.10 and F_{tab} = 3.09 (5%) & 5.07 (1%)

Conclusions

On the basis of experimental results it can be concluded that the flowability of malta powder increases by increasing the amount of carboxy methyl cellulose and tricalcium phosphate while decreases with whole milk powder. Degree of caking decreases by increasing the amount of the carboxy methyl cellulose, tricalcium phosphate and glycerol monostearate while increases with increased amount of whole milk powder. Drying temperature did not show any significant effect on degree of caking. There was no increase in solubility of powder by increasing amount of the carboxy methyl cellulose and whole milk powder whereas it decreases by increasing the level of temperature and tricalcium phosphate.

REFERENCES

Anonymous (2006). Statistical Database of the department of Horticulture and Food Processing, Govt. of Uttarakhand, Chaubattia ,Ranikhet, district-Almora.

Chauca MC, Stringheta PC, Ramos AM and Cal-Vidal J 2005. Effect of the carriers on the microstructure of mango powder obtained by spray drying and its functional characterization. *Innovative Food Science Emerging Technology* (6) 420-428.

Fuchs Y and Barki-Golan R (1979). Post harvest studies with freshly harvested tomatoes intented for export. *Preliminary report no. 77. Research Organization, Israel* **88**.

Jaya S and Das H (2004). Effect of maltodextrin, glycerol monosterate and tricalcium phosphate on vacuum dried mango powder properties. *Journal of Food Engineering* **63**(2) 125-134.

Jaya S, Das H and Maini S (2006). Optimization of maltodextrin and tricalcium phosphate for producing vacuum dried mango powder**.** *International Journal of Food Properties* (9) 13-24**.**

Khuri AI and Cornell JA (1987). Response Surfaces Designs and analyses. Marcel Dekker, Inc. ASQC Quality press, New York, 112-139.

Saeed Akhter, Hamida Abid, Azra Yasmin and Shahid Masood (2010). Preparation and evaluation of physical and chemical characteristics of instant mango juice powder. *Pakistan Journal of Biochemistry and Molecular Biology* **43**(2) 58-60.

Tsami E, Krokida MK and Drouzas AE (1999). Effect of drying method on the sorption characteristics of model fruit powders. *Journal of Food Engineering* **38** 381-392**.**