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Standardization of Pretreatments for Liquefaction of Custard Apple for Spray Drying

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The custard apple variety Madhu and Hybrid 13 recorded an average fruit weight of 288 and 320 g, respectively. The pulp recovery of Madhu (35.53%) was higher compared to Hybrid 13 (35.13 %), whereas the pulp of Madhu was grittier compared to Hybrid 13. The chemical composition of the pulp of both the varieties was more or less similar. The maximum liquefaction of pulp was observed with 2.5 % level of pectinase enzyme at 45ºC for 2.5 h of incubation. The enzyme treatment helped to reduce the viscosity of pulp from 202.31 cP to 76 cP and 374.67 cP to 96 cP in case of Madhu and Hybrid 13, respectively. Maltodextrin @ 20 % level gave more yield of powder. The solubility of powder of Madhu was better than that of Hybrid 13. The powder of Madhu was also found to be better with respect to total sugars and calcium. The score for sensory parameters like colour, flavour, taste, free flowingness and overall acceptability of the fresh powder of Madhu was better than Hybrid 13.

Key words: Custard apple, Pectinase, Viscosity, Maltodextrin, Sensory parameters

Custard apple (*Annona squamosa* L.) is one of the finest fruits introduced in India from tropical America. In India it is cultivated in Andhra Pradesh, Maharashtra, Karnataka, Bihar, Orissa, Assam, and Tamil Nadu. It is a popular fruit with a very short season, lasting for about 3 months a year. Fruits have an edible, soft, granular, juicy and sugary pulp with mild flavor and slight acidity. Storage of the fresh fruits has limitations, because of perishable nature and discolouration of skin during cold storage, which decreases the market value (Purohit, 1995). The ripe fruits, being soft require careful handling during marketing. It is usually eaten as a dessert fruit and finds immense applications in the preparation of beverages and ice creams (Chikhalikar *et al.,* 2000). The fruit contains carbohydrate 23.5 g, moisture 70.5 g, protein 1.6 g, mineral 0.9 g, fiber 3.1 g, calcium 17 mg, phosphorus 47 mg, iron 1.5 mg and vitamin C 37 mg per 100 g of pulp (Bal, 2006). The fruit pulp due to its richness in free sugars, minerals and vitamins is known to serve as blood tonic (Rao, 1974).

The development of bitterness and browning on heating custard apple pulp beyond 55^{0}C was reported by Salunkhe and Desai (1984) and Martinez *et al.,* (1988) and unpleasant off-flavour by heating beyond 65^{0}C (Nanjunda Swamy and Mahadevaiah, 1993). The pulp exposed to air, frozen and thawed undergoes discolouration due to polyphenol-oxidase activity and resulted in loss of quality and value (Pardede *et al*., 1994). Prospero (1993) observed that frozen custard apple pulp without any additives displayed discolouration in 2 h after exposure to ambient temperature. Pulp in frozen state was stored for 12 months without discolouration (Shashirekha *et al*., 2003a). The efforts were made for exploitation of custard apple pulp for dehydrated products (Rajarathnam *et al*., 2003a), jam (Vijayalakshmi *et al*., 2003), jelly (Shashirekha *et al*., 2003b), spray-dried powder (Revathy *et al.* 2003), nectar (Rajarathnam *et al.*, 2003b) and RTS beverage (Singh *et al*., 2002) from custard apple pulp.

Considering the facts of rapid increasing area under custard apple and its minimum shelf life, there is a need to create attractive processing technology for preservation of custard apple pulp. In the present investigation efforts were made to prepare the custard apple powder using spray dryer.

Materials and Methods

The fully matured, healthy and uniform size custard apple fruits of two varieties namely, Madhu and Hybrid 13 were procured from M.P.K.V., Rahuri. The chemicals used in the present investigation were obtained from SD Fine chemicals, Mumbai. Pectinase enzyme was purchased from HiMedia Laboratories Pvt. Ltd., Mumbai.

Preparation of powder

Uniformly ripened fruits of custard apple were selected and pulp was extracted manually. To the pulp ascorbic acid (100 ppm) was added to prevent browning and KMS was added (350 ppm) as preservative. The liquefaction of pulp was carried out by pectinase enzyme @ 1.5, 2 and 2.5 % (w/v) at 30, 35 and 45ºC for 1, 2 and 2.5 h of incubation. The

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liquefied pulp was squeezed through muslin cloth to remove granules in order to prevent clogging of the spray dryer nozzle. To each 500 ml of liquefied pulp, maltodextrin was added @ of 15, 17 and 20 % to prevent stickiness. Tricalcium phosphate was added @ 1 % for the free flow of powder. The pulp was then homogenized thoroughly in D-500 homogenizer operated @ of 12,000 rpm before the preparation of powder. The homogenized pulp was subjected to spray drying by Lubultima laboratory spray dryer (model LU-228). Spray drying was performed at an inlet temperature of 230^{0}C and outlet temperature of 80^{0}C, the aspirator air flow rate was 45 m^3/h, while, the feed flow rate was maintained at 3 ml /min by a peristaltic pump operated at 2.5 kg cm^{-2} air pressure.

Determination of physicochemical parameters

The average diameter of fruit in terms of breadth was recorded with the help of Vernier caliper. Average weight was determined by electronic balance and other parameters like shape and colour were recorded by visual observations. Weight of pulp, seed and peel was calculated and recorded on per cent basis. Powder recovery was determined on the basis of custard apple pulp and expressed in per cent basis. The pulp and powder was analysed for total soluble solid (TSS) with the help of Erma hand refractometer and expressed as ^{0}Brix. The moisture, titratable acidity, ascorbic acid, phosphorus, calcium, total sugars and non reducing sugars of pulp and powder were determined by the procedures stated by Ranganna (1986). The viscosity of fresh pulp and liquefied custard apple pulp samples was measured with Brookfield viscometer (LD DV-2) at a constant temperature (28ºC) by using spindle No.4 at a speed of 60 rpm. The bulk density (g/mL) of powder was determined by gently adding 2 g of powder into an empty 10 mL graduated cylinder. The ratio of powder mass and the volume occupied in the cylinder was recorded as bulk density (Goula and Adamopoulos, 2004). The solubility of the powder was assessed by adding one g of the material to 20 ml of distilled water. The solubility (%) was calculated as per the procedure stated by Cano-Chauca *et al*. (2005).

Sensory evaluation

The powdered samples were evaluated for sensory qualities like colour and appearance, flavour, free flowingness and overall acceptability by a panel of 10 judges on a 9 points hedonic score stated by Amerine *et al.* (1965). The experiment was planned using Factorial Completely Randomised Design and the data was analysed as suggested by Panse and Sukhatme (1967).

Results and Discussion

Physico chemical characteristics of custard apple fruits and pulp

It was revealed from the data that fruits of Madhu variety had oval shape, medium size, green colour with 7.68 cm diameter and 288 g weight (Table 1). Whereas, fruits of Hybrid 13 were triangular in shape, large size, green colour, with 9.60 cm diameter and 320 g weight. The recovery of pulp was higher from Madhu (38.53 %) as compared to Hybrid 13 (35.13 %). The average pulp yield of both the varieties was lower than that reported in literature (Dhumal, 1994) due to non extraction of the gritty pulp adjacent to peel.

Table 1. Physico chemical characteristics of custard apple fruits and pulp

Parameter	Madhu	Hybrid No.13
Fruits		
Shape	Oval	Triangular
Size	Medium	Large
Colour	Green	Light green
Diameter (cm)	7.68	9.60
Weight of fruit (g)	288	320
Aereols (rind) (%)	51.69	56.22
Seeds (%)	09.08	07.60
Pulp (%)	38.53	35.13
Processing losses (%)	00.70	01.05
Pulp		
Colour	Creamy white	Whitish
Grittiness	More	Less
Consistency	Thick	Thick
Viscosity (cP)	202.31	374.67
TSS (^{0}Brix)	23.00	22.00
pH	5.50	5.10
Acidity (%)	0.384	0.192
Moisture (%)	70.00	72.00
Vitamin C (mg/100 gm)	37.00	36.00
Phosphorus (mg/100 gm)	37.00	39.00
Calcium (mg/100 gm)	17.00	16.00
Total sugars (%)	18.00	17.00
Non reducing sugars (%)	2.80	2.03

Beerh *et al.* (1983) reported that on an average, fruit polar length and diameter vary from 6.2 to 9.2 cm and 7.4 to 9.1 cm, respectively in 7 cultivars of custard apple. The portion of gritty pulp (adjacent to peel) and carpellary pulp (around the seed) ranged from 5.9 to 13.2 and 25.3 to 42.0 %, respectively. The total sugar content was higher in Madhu variety and more or less similar values were reported for phosphorus and calcium contents for both the varieties. The results for nutritional composition of custard apple pulp were in good agreement with Kolekar (2002) and Bal (2006).

Liquefaction of pulp

The liquefaction of pulp with pectinase enzyme is known to reduce the viscosity of pulp facilitating the spray drying by avoiding clogging of spray dryer nozzle. The reduction in viscosity was maximum and statistically significant in C3 (2.5 %) and T3 (45^{0}C) in both the varieties (Table 2). The results in case of Madhu and Hybrid 13 indicated that significant

Table 2. Viscosity measurement of pulp

Treatments	Madhu(cP)	Hybrid No.13(cP)
C_1	175.33	348.67
C_2	158.67	286.33
C_3	129.67	170.67
S.E. ±	1.85	2.83
CD at 5 %	5.51	8.42
T_1	224.33	380.67
T_2	146.67	263.00
T_3	92.60	162.00
S.E. ±	1.85	2.83
CD at 5 %	5.51	8.42
C T A	250.00	376.00
$C_1T_2A_2$	174.00	346.00
$C_1T_3A_3$	102.00	224.00
C T A	228.00	397.00
C T A	148.00	296.00
$C_2T_3A_3$	100.00	166.00
$C_3T_1A_1$	195.00	269.00
$C_3T_2A_2$	98.00	127.00
$C_3T_3A_3$	76.00	96.00
S.E. ±	3.21	4.91
CD at 5 %	9.54	14.59

C: Concentration of enzyme, T: Temperature of incubation and A: Period of incubatic n
C_1: 1.5 %, C_2: 2.0 % and C_3: 2.5 %; T_1: 30ºC, T_2: 40ºC and T_3: 45ºC
A_1. 1 h, A_2. 2 h and A_3. 2.5 h

reduction in viscosity from 175.33 to 129.67 cP ar from 348.67 to 170.67 cP, respectively were observe in C_3 (2.5 % enzyme concentration). The effect of different temperatures with 2.5 % enzyme concentration showed higher reduction in viscosit y (92.60 cP) at 45°C in T3. Interaction effect of three factors resulted in statistically significant reduction in viscosity of pulp of Madhu and Hybrid 13 up to 7 and 96 cP in treatment $C_3T_3A_3$ (2.5 % enzym concentration at 45ºC for 2.5 h).

The pulp of different mango varieties treated fo r %

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Tuyen *et al*. (2010) observed overall good quality Gac powder by spray-drying at inlet temperature of 120ºC and maltodextrin concentration at 10 % w/v. Roustapour *et al.* (2006) revealed that an addition of 10 % silicon dioxide and 20 % maltodextrin to lime juice was optimum for successful drying of lime juice in a pilot plant spray dryer. Mango juice (12 ºBrix) added with additives such as maltodextrin, arabic gum and waxy starch, at a concentration of 12 % and microcrystalline cellulose reduced stickiness of spray dried mango powder (Milton Cano Chauca *et al.*, 2004).

Physical and chemical characteristics of custard apple powder

The physical characteristics of a powder preparation affect the end use qualities. Custard apple powder obtained with 20 % maltodextrin in case of var. Madhu showed a bulk density of 0.42 g/cc and solubility of 91.50 %, whereas powder from Hybrid 13 possessed bulk density of 0.37 g/cc and solubility 88.40 % (Table 3). The total sugars content of powders of Madhu and Hybrid 13 were 24.00 and 22.00 %, respectively, whereas reducing sugars were 22.50 and 19.90 %, in the respective fruits. Phosphorus content was higher in the powder of Hybrid 13 and calcium content exhibited inverse results.

Table 3. Physical and Chemical characteristics of powder

Parameter	Madhu	Hybrid No.13
Bulk density (g/cc)	0.42	0.37
Solubility (%)	91.50	88.40
TSS (ºBrix)	32.00	30.00
Total sugars (%)	24.00	22.00
Non reducing sugar (%)	2.50	2.10
Reducing sugars (%)	22.50	19.90
pH	5.40	5.30
Acidity (%)	0.40	0.20
Moisture (%)	7.70	8.40
Vitamin C (mg/100 g)	38.00	38.00
Phosphorus (mg/100 g)	40.00	42.00
Calcium (mg/100 g)	20.00	19.00

Tuyen *et al*. (2010) observed reduction in bulk densities of Gac aril powder with increased level of maltodextrin and also drying temperature. The maltodextrin treatment has a high degree of solubility (above 90 %) of mango powder (Milton Cano-Chauca, 2004) and pomegranate juice powder (Shima Yousefi *et al.,* 2011)

Sensory evaluation

The data indicated that colour and appearance of fresh powder of Hybrid13 was higher (9.0) than that of Madhu (8.2). However, the sensory score for flavour, taste, free flowingness and overall acceptability was higher for Madhu variety.

The current study indicated that the chemical composition of the pulp of both the varieties was more or less similar. The pectinase enzyme treatment helped to reduce the viscosity of custard apple pulp. Addition of maltodextrin @ 20 % gave more yield of powder. The powdered pulp of Madhu

variety of custard apple was found to be better with all sensory qualities when compared to the sample prepared with Hybrid 13.

References

Amerine, M.A., Pongborn, R.M. and Roessler, E.B.1965. Principles of Sensory Evaluation of Food. Academic Press, New York. p: 480.

Bal, J.S. 2006. Fruit growing. 2nd Edn. Kalyani Publication, New Delhi. p: 78.

Beerh, O.P., Giridhar, N. and Raghuramaiah, B. 1983. Custard apple (*Annona squamosa* L.) Part-I. Physico-chemical characteristics and chemical composition. *Indian Food Packer.* **37-38**(3):77-81.

Cano-Chauca, M.,Stringheta, P.C., Ramos, A.M. 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 Sci. and Emerging Technol.* **6** :420 – 428.

Chadha, R., Kumbhar, B.K. and Sarkar, B.C. 2003. Enymatic hydrolysis of carrot for increased juice recovery. *J. Food Sci. Technol*. **40**(1): 35-39.

Chikhalikar, N. V., Sahoo, A. K., Singhal, R. S. and Kulkarni, P. R. 2000. Studies on frozen pourable custard apple (Annona squamosa L.). *J. Sci. Food and Chem.* **80**:1339–1342.

Dhumal, N.S. 1994. Studies on the processing of custard apple (*Annona squamosa* L.). M.Sc. Thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri.

Goula, A.M. and Adamopoulos, K.G. 2004. 'Influence of spray drying conditions on residue accumulation-Simulation using CFD. *Drying Technol.* **22** (5): 1107 – 1128.

Kareem, S.O. and Adebowale, A.A. 2007. Clarification of orange juice by crude fungal pectinase from citrus peel. *Nig. Food J.* **25**(1):130-137.

Kolekar, T.T. 2002. Extraction and preservation of custard apple (*Annona squamosa* L.) pulp. M.Sc. (Agri.) Thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri.

Martinez, C.M., Medina, L.S., Fans, M. J. and Gill, S. 1988. Cherimoya. (Annona cherimola Mill), polyphenol oxidase, monophenolase and dihydroxyphe-nolase activities. *J. Food Sci.* **53** : 1191–1194.

Milton Cano-Chauca, Paulo, C., Stringheta, Luiggi, D., Sardagna and Jose Cal-Vida. 2004. Mango juice dehydration spray drying using different carriers and functional characteristion. Proceedings of the 14th International Drying Symposium (IDS 2004). 22-25 August, Sao Paulo, Brazil.

Nanjunda Swamy, A. M., and Mahadevaiah, M. 1993. Fruit processing. In:Advances in horticulture, K. L. Chadha, and O. P. Pareik (Eds.), Malhotra Publishing House. New Delhi. **4.** p: 1835.

Panse, V.G. and Sukhatme, P.V. 1967.Stastical Methods for Agricultural Workers.2nd edn, Indian Council of Agril. Research. New Delhi.

Pardede, E., Buckle, K.A. and Srzednicki, G. 1994. Control of browning during thawing of custard apple pulp. *Food Australia*, **46**(5):205–206.

Prospero, R.B. 1993. The stability of frozen custard apple pulp (*Annona atemoya*) M. App. Sci. thesis. Kensington: University of New South Wales.

Purohit, A.G. 1995. Annonaceous fruits. In Hand book of fruit science and technology. D.K. Salunkhe and S. S. Kadam (Eds.), Marcel Dekker Press. New York. pp: 377–385.

Rajarathnam, S., Shashirekha, M. N., Vijayalakshmi, M. R., and Revathy, B. 2003a. A process for the preparation of dehydrated product from custard apple. Indian patent application no. 382/DEL/03.

Rajarathnam, S., Shashirekha, M. N., Vijayalakshmi, M. R., and Revathy , B. 2003b. A process for the preparation of nectar from custard apple.Indian patent application: no. 402/DEL/03.

Ranganna, S. 1986. Manual of Analysis of fruit and vegetable products. Tata Mc Graw Hill Publishing Co. Ltd., New Delhi. p: **109**.

Rao, S. N. 1974. Annonas -The legendary fruit. *Indian Horticulture.* **19**(3) : 19-21.

Revathy, B., Vijayalakshmi, M.R., Shashirekha, M.N. and Rajarathnam, S. 2003. Custard apple powder and a method for preparation. Indian patent application no. 465/DEL/04.

Roustapour, O.R., Hosseinalipur, M. and Ghobadian, B. 2006. An Experimental Investigation of lime juice drying in a pilot plant spray dryer. *Drying Technol.* **24**(2): 181-188.

Salunkhe, D.K., and Desai, B. B. 1984. Custard apple. In Post-harvest biotechnology of fruits, CRC Press, Boca Raton, FL. p: 133.

Shashirekha, M.N., Rajarathnam, S., Vijayalakshmi M.R. and Revathy, B. 2003a. A process for the preparation of shelf stable custard apple pulp. Indian patent application no. 525/NF/03.

Shashirekha, M. N., Rajarathnam, S., Vijayalakshmi, M. R. and Revathy, B. 2003b. A process for the preparation of jelly from custard apple. PCT patent application no. PCT 0434.

Shima Yousefi, Zahra Emam-Diomeh and Mousavi S.M. 2011. Effect of carrier type and spray drying on the physicochemical properties of powdered and reconstituted pomegranate juice (*Punica Granatum L.*). *J. Food Sci. Technol.* **48**(6): 677–684.

Shrestha, A. K., Ua-arak, T., Adhikari, B. P., Howes, T., and Bhandari, B. R. 2007. Glass transition behavior of spray dried orange juice powder measured by differential scanning calorimetry (DSC) and thermal mechanical compression test (TMCT). *Intr. J. Food Properties*. **10**(3): 661–673.

Singh, N. I., Vijayalakshmi, M. R., Shashirekha, M. N., Revathy, B. and Rajarathnam, S. 2002. Ready-to-serve beverage from custard apple by microfiltration. Indian patent application no. NF-103.

Sreenath, H.K., Sudarshana, K.R. and Santhanam, K. 1999. Enzymatic liquefaction of same varieties of mango pulp. *Eur. Food Research and Technol.* **209**: 57-62.

Truong, V., Bhandari, B. R., & Howes, T. 2005. Optimization of concurrent spray drying process of sugar-rich foods. Part I -Moisture and glass transition temperature profile during drying. *J. of Food Engg.* **71**(1): 55–65.

Tuyen, C., Kha Minh, Naguyen, H. and Paul, D. 2010. Effect of spray drying conditions on the physicochemical and antioxidant properties of the Gac fruit aril powder. *J. Food Engg.,* **98**: 385-392.

Vijayalakshmi, M.R., Shashirekha, M.N., Revathy, B. and Rajarathnam, S. 2003. A process for the preparation of jam from custard apple. PCT Patent Application No. PCT 0322.

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