Standardisation and quality evaluation of Queensland arrowroot (*Canna edulis* L.) based custard powder

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Abstract

Roots and tubers are the third important food crop of mankind after cereals and pulses. Queensland arrowroot (*Canna edulis* L.) is an underutilized tuber grown in many countries for its edible starchy rhizome. Canna starch is easily digestible and has good potential in food application. Canna starch powder is exceptional for its pure white colour and fine texture and these quality attributes are retained during storage. Ready-to-use custard powder was standardized using canna starch and corn flour in different combinations. The overall acceptability of custard prepared exclusively with rhizome starch (35%) was found to be 8.69 and was selected as the best combination. The standardized custard powder had excellent sensory and microbial qualities and was found to be self-stable. Queensland arrowroot starch is a new promising starch source suitable for the development of various value added products.

Keywords: Custard powder, Organoleptic qualities, Queensland arrowroot, Starch

Introduction

Roots and tubers are the third important food crop of mankind after cereals and pulses. They constitute either staple or subsidiary food for about one fifth of the world's population. According to FAO (2012) 'nutrition-sensitive' growth in a country can be ensured by supporting increased dietary diversity. In this context, tropical tuber crops like cassava, sweet potato, elephant foot yam, yams, taro, tannia, yam bean, arrowroot etc. are important for ensuring food and nutritional security of the country. Queensland arrowroot (*Canna edulis* L.*)*, belonging to the family Cannaceae, is a perennial herb grown in many countries for its edible starchy rhizome. It is an outstandingly versatile underutilized crops of tropics. Canna starch is easily digestible and has good potential in food application (Moorthy et al., 2002). Edible Canna is an alternative starch source and is reported to produce 30.4 - 38.4 Mg ha^{-1} of rhizomes with starch content of about 13 per cent (Piyachomkwan et al., 2001). Canna starch has excellent eating qualities and is suited to develop transparent oriental style noodles, a lighter and crispier baked product (Jeeva et al., 2004). Canna starch swells, solubilizes and thereby develops considerable viscosity as well as thickening character (Perez and Lares, 2005). Awareness about the variability of Canna starch properties and knowledge about the innumerable products which can be produced from the starch have been scanty and hence the potential application is limited. In the present context of rapid increase of population and consequent shortage of food grains, utilization of various types of unutilized and underutilized tuber crops is essential. Hence, the present study was undertaken to evaluate the suitability of Canna starch powder for product development and to evaluate its storage qualities.

Materials and Methods

Queensland arrowroot (*Canna edulis* L.) plants were identified from local homesteads. Fully matured rhizomes of ten months' maturity were collected from the homesteads. All other materials like corn

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flour, milk powder, cashew nuts and sugar required for product development were purchased from the local market.

Preparation of rhizome starch powder

Starch extraction was carried out as suggested by Moorthy et al. (2002). Rhizomes were washed, peeled and pulped in a Remi blender with ten parts of water. The pulp was mixed with 5 parts of water, strained through a 150 mesh sieve and allowed to settle. Resuspension and resettling were carried out several times and the deposited cake was dried in sunlight and 200 g of powder was stored in airtight glass container at ambient room temperature (28° C–32° C). The sensory and microbial qualities were analyzed initially as well as at the end of third month of storage.

Standardisation of custard powder and quality evaluation

Ready-to-use custard powder was standardised by mixing starch powder with corn flour at different proportions (Table 1). 35 per cent starch was used in custard powder along with 15 per cent milk powder, 45 per cent sugar and 5 per cent powdered cashew nuts and blended well. Custard powder prepared using 100 per cent corn flour was taken as the control (T_1). Sensory evaluation of ready-to-use custard powder prepared from starch powder was conducted by preparing custard. The quantity of water and time required to make custard of acceptable consistency was standardised by repeated trials. For this, 20 g of the custard powder (T_1 to T_7) was mixed with varying quantities of water to form slurry without lumps and boiled with frequent stirring and cooked till it attained the consistency of custard. The quantity of water and time taken to prepare custard from the seven treatments under study are presented in Table 2.

Table 2. Quantity of water required and time taken for the preparation of custard

Treatments	Water (ml 20 g^{-1})	Time (minutes)
T_1	180	12
T_2	175	10
T_3	140	8
T_4	150	8
T_5	160	6
T_6	160	5
T_7	170	3

From the various treatments used for the standardisation of ready-to-use custard powder, the most acceptable treatment was selected on the basis of mean scores obtained for organoleptic qualities. The sensory evaluation of the products was carried out using score card method (Swaminathan, 1974) by a selected panel of fifteen judges as suggested by Jellinek (1985). Score card containing six quality attributes like appearance, colour, flavour, texture, taste and overall acceptability was prepared for the evaluation of the product. Each of the above mentioned qualities were assessed by a nine point hedonic scale. The scores of organoleptic evaluation were analysed by Kendall's coefficient of concordance (W) to assess the degree of agreement among the judges. Percentage relative increase was calculated for the enumeration of microbial count. The data were also analysed using t test.

The best combination of custard powder (150 g) was packed in metalised polythene laminate pouches and stored at ambient temperature (30°C–

Table 1. Quantity of ingredients used for the standardisation of ready to use custard powder from starch powder.

Ingredients (g)	T_1	T_2	T_3	T_4	T_5	T_6	T_7
Starch powder	-	35	31.5	28	24.5	21	17.5
Corn flour	35	-	3.5	7	10.5	14	17.5
Milk powder	15	15	15	15	15	15	15
Sugar	45	45	45	45	45	45	45
Cashew nuts (powdered)	5	5	5	5	5	5	5

34°C) at an average relative humidity of 73.9% for a period of three months. Microbial and organoleptic qualities of the stored product were also assessed. All the analyses were conducted in three replications.

The total microbial count of starch powder and prepared custard powder were enumerated initially and after a period of three months. The method used for evaluation of total microbial count was serial dilution and plate count method as described by Agarwal and Hasija (1986). Enumeration of total microbial count was carried out using nutrient agar media for bacteria, potato dextrose agar media for fungus and sabouraud's dextrose agar media for yeast. The dilution used for bacteria was 10^{-5}, and for yeast and fungi was 10^{-3}. Presence of storage insects was assessed by examining the flour and starch under the microscope. Flour was sieved first with 60 BL sieve and observed under the microscope. The insect infestation in stored products was assessed initially and after a period of three months by visual examination. All the analyses were carried out in triplicates.

Results and Discussion

Storage qualities of rhizome starch powder

Canna starch powder showed retention of sensory qualities during storage. Detectable flavour change was not observed throughout the storage period. The texture of the starch powder and flour were found to be fine, and uniform in nature and caking was practically absent during the entire storage period. No significant change was observed in quality attributes like colour, flavour and texture of both rhizome flour and starch powder at the end of storage period. The microbial qualities of the stored starch powder were determined initially and at the end of three months of storage. Microbial counts in starch powder during storage are presented in Table 3. The initial bacterial load in starch powder was found to be 2.66×10^5 cfu g^{-1} which increased to 3.44×10^5 cfu g^{-1} after three months of storage. Misra and Kulshrestha (2002) detected a total bacterial count of $1.71x10^3$ cfu g^{-1} in potato flour which gradually increased to $1.8\ x10^3$ cfu g^{-1} at ambient temperature and $1.8\ x10^3$ cfu g^{-1} at refrigerated temperature during the storage period of six months. Bera et al., (2001) opined that the growth of bacteria and fungi in the food sample is influenced by moisture content, high or low humidity, temperature of storage and type of sample. The fungal growth was found to be 1.66×10^3 cfu g^{-1} initially and it increased to 2.33×10^3 cfu g^{-1} at the end of storage. The initial yeast growth in starch powder was found to be 1.00×10^3 cfu g^{-1} which increased to 2×10^3 cfu g^{-1} at the end of storage period. A gradual increase in the microbial count was observed during storage. The increase in fungal count during storage might be due to the increase in moisture content of the flour during storage as reported by Kapoor and Kapoor (1990). The initial yeast growth in starch powder was found to be 1.00×10^3 cfu g^{-1} which increased to 2×10^3 cfu g^{-1} at the end of storage period. Different studies conducted by Sharon (2003), Bhatiwada (2007), and Hanmant (2010) indicated an increase in the fungal count in bread fruit flour, grain amaranth flour and mango seed kernel flour respectively during storage. Various extrinsic and intrinsic factors like moisture, relative humidity, storage temperature, type of samples, storage containers etc. might have affected the microbial count of flour during storage.

Table 3. Microbial count in starch powder during storage

Starch powder	Microbial population (cfu g^{-1})		
	Bacteria$\times10^5$	Fungi $\times10^3$	Yeast $\times10^3$
Initial	2.66	1.66	1.00
Final	3.44	2.33	2.00

All values are means of 3 independent enumerations

Quality evaluation of standardized custard powder

The mean scores obtained for various quality attributes like appearance, colour, flavour, taste and overall acceptability of custard are given in Table 4. Among the seven treatments tried, custard prepared with custard powder made exclusively with corn flour (control) obtained the highest mean score of 8.96 with a mean rank score of 5.90 for

Table 4. Mean scores for different organoleptic qualities of custard

Treatments	Characters					
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_1	8.96(5.90)	8.84(5.85)	8.81(6.00)	8.85(6.25)	8.85(6.15)	8.96(5.95)
T_2	8.67(4.50)	8.64(4.85)	8.52(4.55)	8.46(4.70)	8.64(5.60)	8.69(5.00)
T_3	8.61(4.30)	8.46(3.55)	8.45(4.50)	8.49(4.60)	8.47(5.45)	8.68(4.70)
T_4	8.46(3.65)	8.49(3.95)	8.20(3.20)	8.49(4.33)	8.12(3.00)	8.45(3.55)
T_5	8.24(2.75)	8.40(3.50)	8.13(3.20)	8.05(2.40)	8.09(3.30)	8.58(2.95)
T_6	8.47(3.80)	8.50(4.05)	8.15(3.60)	8.13(3.40)	8.14(3.05)	8.24(2.90)
T_7	8.34(3.10)	8.17(2.25)	8.04(2.95)	8.01(2.55)	7.99(2.45)	8.34(2.95)
Kendall's (W) test	0.298**	0.341**	0.290**	0.433**	0.523**	0.412**

(Figures in parenthesis indicates mean rank scores) **significant at 1% level

T_1 - 100% corn flour (control) T_2 - 100% starch powder

T_3 - 90% starch powder + 10% corn flour T_4 - 80% starch powder + 20% corn flour

T_5 - 70% starch powder + 30% corn flour T_6 - 60% starch powder + 40% corn flour

T_7 - 50% starch powder + 50% corn flour

appearance. Custard prepared exclusively with rhizome starch powder obtained a mean score of 8.67 followed by 8.61 (T_3), 8.46 (T_4), 8.47 (T_6), 8.34 (T_7) and 8.24 (T_5) for appearance. The higher scores for appearance may be due to the white creamy nature of prepared canna starch powder. Custard prepared with 100 per cent starch powder obtained a mean score of 8.64 for colour and 8.52 for flavour. The mean scores for texture of different treatments varied from 8.01 to 8.49 with mean rank score in between 2.55 to 4.60. A study conducted by Marwaha and Sandhu (1999) on potato custard powder indicated that the addition of starch or starch flour combination acted as thickeners and were effective in bringing the desired consistency for the custard. For taste, custard prepared exclusively with starch powder had a mean score of 8.96 with a rank score of 5.

The overall acceptability of custard prepared exclusively with rhizome starch was found to be 8.69. The mean scores of custard prepared with different combinations of corn flour and starch powder were found to be 8.68 (T_3), 8.58 (T_5), 8.45 (T_4), 8.34 (T_7) and 8.24 (T_6). The custard prepared with 100 per cent rhizome starch powder (T_2) obtained maximum score for appearance (8.67), colour, flavor (8.52) and taste (8.64). Better texture also was noticed in T_2 with a mean score of 8.46. A study conducted by Moorthy (2004) reported that canna starch is highly suitable for products like pudding as it have excellent paste clarity. Puddings prepared with tuber starch in combination with corn starch were significantly superior in texture, flavor, colour and overall acceptability (Salwa et al., 2010). A study on sensory properties of cassava starch-based custard powder (CbCP) indicated that custard powder prepared with 94% starch was highly acceptable (Awoyale et al., 2015).

Since, the most desirable characteristics of custard like colour, texture and taste were found to be good in T_2, it was selected as the most acceptable treatment for custard powder. The organoleptic scores of different quality were analysed using Kendall's (W) test and found to be significant at 1% level. Hence, the mean scores were taken to differentiate the preference of the judges with regard to the quality attributes of different treatments. Agarwal et al., (2010) indicated mean scores of 8.0 (colour and appearance), 7.9 (flavor), 8.0 (taste) and 8.0 (overall acceptability) for custard.

Storage qualities of standardized custard powder

The organoleptic qualities of custard powder during storage were evaluated by preparing custard and the changes in mean scores for different quality attributes are shown in Table 5.

Table 5. Mean scores for organoleptic qualities of custard (100 % starch powder) during storage

Parameters	Period of storage		t value
	Initial	Final	
Appearance	8.70	8.46	1.56^{NS}
Colour	8.66	8.00	4.55^{**}
Flavour	8.46	7.60	6.50^{**}
Texture	8.53	7.80	4.85^{**}
Taste	8.66	8.30	2.79^{**}
Overall acceptability	8.70	8.36	2.40^{**}

NS – Non Significant Significance at 5% level

The mean score for the appearance of custard slightly decreased from 8.70 to 8.46 by the end of third month of storage. Initially, the mean score obtained for colour of the custard was 8.66 which decreased to 8.00 at the end of three months of storage. The initial mean scores for flavour and texture were 8.46 and 8.53 respectively which decreased significantly at the end of storage. The mean score for taste of the custard was 8.66 initially and it decreased to 8.30. Overall acceptability score of 8.70 was obtained initially which decreased to 8.36 after three months of storage. The decrease in mean scores of all organoleptic parameters except appearance was found to be statistically significant at 5 per cent level. The decrease of the taste might be due to absorption of moisture by the custard powder during storage. This moisture absorption might have stimulated the activity of lipase which splits up fat into free fatty acids and glycerol, ing rancidity (Akhtar et al., 2005).

Bacterial and fungal growth was below the detectable level in custard powder initially and a safe population was observed at the end of three months of storage. Initially, yeast growth was not detected and yeast count of 0.33×10^{3}cfu g^{-1} was observed in custard powder at the end of three months of storage. The custard powder was free from insect infestation initially and after three months of storage. The low microbial load and lack of infestation may be due to the packaging of the product in metalised polythene laminated pouches which is an effective moisture barrier. In support to this, Raj (2011) also did not notice any insect infestation in weaning foods up to three months of storage in laminated pouches. According to Nasir et al. (2003) moisture is an important factor which affects the insect infestation in wheat flour.

The present study was carried out to standardize custard powder based on Queensland arrowroot starch. Canna starch powder is exceptional for its pure white colour and fine texture and is extremely suited for the preparation of ready-to-use custard powder. The standardized custard powder had excellent sensory and microbial qualities and was found to be self-stable. Custard of desired consistency can be obtained from canna starch based custard powder without adding any other starch source or thickening agents. Queensland arrowroot starch is a new promising starch source suitable for the development of various value added products.

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