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Functional Properties of Precooked Taro Flour in Sorbets

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ABSTRACT

The replacement of commercial food gums such as locust bean gum (LBG), carboxymethylcellulose (CMC) and carrageenan gum (CG) with precooked taro flour in tropical fruit (pineapple, guava, pineapple and passion fruit) sorbet manufacturing was investigated. Functional properties such as viscosity, firmness and melting characteristics were compared. Results indicated that precooked taro flour can replace LBG, CMC and CG successfully without noticeable change in functional properties.

INTRODUCTION

Sorbet is a frozen dessert made from sugar, water, fruit acid, color, fruit or fruit flavoring and stabilizer (crystal inhibitor). It provides a rich, smooth and creamy product without the use of fat or dairy ingredients (Anon., 1985). The percentage uses of common stabilizers in sorbet-type desserts are 0·10% carrageenan gum, 0·20% carboxymethylcellulose (CMC), or 0·25% locust bean gum (Glicksman, 1969; Arbuckle, 1977). Combinations of different gums and modified starches are also used to take advantage of their synergistic effect.

Taro (*Colocasia esculenta* L. Schott) contains 70 to 80% starch on a dry weight basis (Payne *et al.*, 1938; Tu *et al.*, 1979) with a very small granule size of 2 to 5 μm in diameter (Amin, 1955). It is also very rich in gums (mucilages). Taki *et al.* (1972) were successful in preparing about 100 g of purified gums from 1 kg of fresh taro corms, whereas Gaind *et al.* (1968) reported the extraction of 4·0–10·7% crude taro mucilages with boiling water from taro

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corms and tubers, respectively. However, with this rich source of complex carbohydrates, very few food-related applications of taro starch and/or gums have been explored. Nip (1979*a*,*b*) reported on the drum-drying properties and storage stability of tropical fruit–taro mixtures. Gaind *et al.* (1968, 1969) studied the binding and emulsifying properties of crude taro gums.

The purpose of this study was to explore the applicability of replacing commercial food gums with precooked taro flour in sorbet type products.

MATERIALS AND METHODS

Raw materials

The commercial white taro (Apii variety), one of the most common wetland taro grown in Hawaii, was used. Guava (*Psidium guajava* L., variety Beaumont) was prepared in the form of purée by maceration of the fruit in a silent cutter and removal of the seed and stone cells through a pulper equipped with a 0·68 mm (0·027 in) screen. Commercial papaya (*Carica papaya* L.), pineapple (*Ananas comosus* L.), and passion fruit (*P. edulis* Sims *F. Flavicarpa* Deg.) purées were obtained from local Hawaiian processors.

Preparation of precooked taro flour

About 11 kg fresh taro corms were washed and cooked in the retort at 116·6°C for 1 h to inactivate the acridity property in taro (Nip, 1979*a*,*b*). The cooked corms were hand-peeled, sliced into 5 mm thick slices, air-dried at 60°C for 24 h and ground with a meat grinder. The coarse flour was further reduced by passage through a series of screens of a Fitzmill, the last screen opening being 0·18 mm in diameter. About 3 kg precooked taro flour was prepared, with a recovery of 27%.

Mucilage content of precooked taro flour

Jacob's procedure (1958) with minor modification was applied to estimate the mucilage content in the precooked taro flour. A 5 g sample (dry weight) was extracted 3 × with 200 ml petroleum ether to remove the fatty materials. The residual petroleum ether was evaporated on a waterbath at 40°C. Fifty milliliters distilled water were added and stirred. Ten milliliters 40% trichloroacetic acid were added and stirred vigorously to settle the proteins. The mixture was allowed to stand for 5 min then centrifuged at 3400*g* for 15 min. The supernatant was mixed with 5 vol 95% ethyl alcohol with constant stirring and allowed to stand for 5 min. Ammonium hydroxide solution (58%) was added drop by drop until the mixture became alkaline (pH 8·0) and it was allowed to stand for 5 min. Then 10 drops 37% HCl (to pH 1·0) were added with vigorous stirring. The precipitate was filtered through a tared sintered glass funnel, washed with acetone, dried at 40°C for 24 h and weighed. The average of seven replicated determinations of mucilage content was 9·03 ± 0·01%.

Viscosity of taro powder

The viscosities of taro flour solutions (1·5, 2·0, 2·5 and 3%) were compared with the viscosities of 0·20% carboxymethylcellulose (CMC), 0·10% carrageenan gum (CG) and 0·25% locust bean gum (LBG) (Glicksman, 1969; Arbuckle, 1977), which are the most popular gums used in the manufacturing of sorbet. Two hundred milliliters of each solution were heated at 79·4°C for 25 s to gelatinize the starch in the taro flour (Moy *et al.*, 1977). All seven solutions were cooled to room temperature (23·5°C) for measurement with the Ostwald Viscometer (Capillary diameter, 0·4 ± 0·01 mm, constant D, 0·014). The flow-through time for each solution was as follows: 0·25% locust bean gum–248 s; 0·1% carrageenan gum–194 s; 0·20% carboxymethylcellulose—155 s; 1·50% taro—130 s, 2·0% taro—150 s, 2·5% taro—212 s and 3·00% taro—262 s. Taro at a concentration of 2·5% was used in further studies since its viscosity falls within the range of those of the gums used commercially.

Formulation and preparation of sorbet

Based on the mucilage content in the precooked taro flour, viscosity measurements of the various stabilizers and the °Brix and acidity of the fruit purées, appropriate amounts of each ingredient were formulated into the tropical fruit sorbets (Table 1) and tropical fruit–taro sorbets (Table 2).

The sweetening agents and taro flour (as stabilizer) were thoroughly mixed to facilitate solubilization. Water was added to the dry ingredients and the mixture thoroughly agitated. This sorbet base was gelatinized at 79·4°C for 25 s with continuous agitation, then cooled to 2°C. Just before freezing, fruit purée/juice concentrate, taro purée in the case of fruit–taro sorbet, and 50% citric acid solution were added to the base mix and the final sorbet mix was frozen in the batch freezer (Model 71, Richmond Cedar Works Manuf. Co., Danville, VA, USA). Freezing was continued until the overrun reached 30%. After freezing, soft sorbet was poured into 177 ml (6 fl oz) plastic cups which were immediately covered and placed in a −25°C hardening freezer for 24 h. To simulate commercial storage conditions, the hardening sorbets were stored in a −15°C storage chamber, pending physical tests and sensory evaluation.

For taro sorbet, only taro was used as the flavoring ingredient. Taro purée was prepared and added to the sorbet base mix. No citric acid was added in

TABLE 1
Fruit Sorbet Formulae using Commercial Stabilizers and Precooked Taro Flour

Ingredients (% by wt)	*Stabilizer*															
	Guava[a]				*Papaya*[b]				*Pineapple*[c]				*Passion fruit*[d]			
	LBG[e]	*CG*[f]	*CMC*[g]	*Taro*	*LBG*[e]	*CG*[f]	*CMC*[g]	*Taro*	*LBG*[e]	*CG*[f]	*CMC*[g]	*Taro*	*LBG*[e]	*CG*[f]	*CMC*[g]	*Taro*
Cane sugar	15·00	15·00	15·00	15·00	13·00	13·00	13·00	13·00	10·00	10·00	10·00	10·00	15·00	15·00	15·00	15·00
Corn syrup solids (36DE)	10·00	10·00	10·00	10·00	10·00	10·00	10·00	10·00	8·00	8·00	8·00	8·00	10·00	10·00	10·00	10·00
Stabilizer	0·25	0·10	0·20	2·50	0·25	0·10	0·20	2·50	0·25	0·10	0·20	2·50	0·25	0·10	0·20	2·50
Fruit	20·00	20·00	20·00	20·00	20·00	20·00	20·00	20·00	20·00	20·00	20·00	20·00	20·00	20·00	20·00	20·00
Citric acid	0·20	0·20	0·20	0·20	0·07	0·07	0·07	0·07	0·25	0·25	0·25	0·25	0·00	0·00	0·00	0·00
Water	54·55	54·70	54·60	52·30	56·68	56·83	56·73	54·43	61·50	61·65	61·55	59·25	54·75	54·90	54·80	52·50
Total	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

[a] Guava purée—10·0 °Brix, 1·28% total acidity, 77% moisture.
[b] Papaya purée—19·0 °Brix, 0·33% total acidity, 79·53% moisture.
[c] Pineapple juice concentrate—45·0 °Brix, 4·49% total acidity, 53·92% moisture.
[d] Passion fruit purée—24·5 °Brix, 5·75% total acidity, 71·05% moisture.
[e] LBG, locust bean gum.
[f] CG, carrageenan gum.
[g] CMC, carboxymethylcellulose.

TABLE 2
Tropical Fruit–Taro Sorbet Formulae using Precooked Taro Flour as Stabilizer

Ingredients (% by wt)	*Guava:taro ratio*			*Papaya:taro ratio*			*Pineapple:taro ratio*			*Passion fruit:taro ratio*		
	2:1	*3:2*	*1:1*	*2:1*	*3:2*	*2:1*	*2:1*	*3:2*	*2:1*	*2:1*	*3:2*	*2:1*
Cane sugar	15·00	15·00	15·00	13·00	13·00	13·00	10·00	10·00	10·00	15·00	15·00	15·00
Corn syrup solids (36DE)	10·00	10·00	10·00	10·00	10·00	10·00	8·00	8·00	8·00	10·00	10·00	10·00
Stabilizer	2·50	2·50	2·50	2·50	2·50	2·50	2·50	2·50	2·50	2·50	2·50	2·50
Fruit[a]	13·30	12·00	10·00	13·30	12·00	10·00	13·30	12·00	10·00	13·30	12·00	10·00
Taro purée[b]	6·70	8·00	10·00	6·67	8·00	10·00	6·70	8·00	10·00	6·70	8·00	10·00
Citric acid	0·13	0·12	0·10	0·05	0·04	0·04	0·17	0·15	0·13	0·00	0·00	0·00
Water	52·37	52·38	52·40	54·45	54·46	54·46	59·33	59·35	59·37	52·50	52·50	52·50
Total	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

[a] Guava purée—10·0 °Brix, 1·28% total acidity, 77% moisture; Papaya purée—19·0 °Brix, 0·33% total acidity, 79·53% moisture; Pineapple juice concentrate—45·0 °Brix, 4·49% total acidity, 53·92% moisture; Passion fruit purée—10·0 °Brix, 1·28% total acidity, 85·55% moisture.
[b] Taro purée—15% precooked taro flour, 85% water.

order to give the product the natural taro flavor. Taro flour was also used as a stabilizer in this product. The procedure for preparation of taro sorbet was similar to that for the fruit sorbet described earlier.

Viscosity of sorbet mix

The viscosities of the final mixes were determined with a 10 ml pipette, having a 0·78 cm diameter and 1 mm opening, held in a vertical position. The temperature of each sample and the pipette were maintained at room temperature (23·5°C). Flow time of each mix was recorded in seconds. Triplicate measurements were conducted for each sample.

Firmness (hardness) test

The hardness of each sorbet was measured with an Instron Universal Testing Machine, Model 1102 (Instron Corp., Canton, MA, USA), fitted with the Magness–Taylor probe (0·852 cm diameter). The crosshead speed was set at 31·75 cm/min (12·5 in/min) and the chart speed was adjusted to 24·77 cm/min (9·75 in/min). Each sample was drawn from the −25°C hardening freezer just before measuring the hardness. The probe was allowed to penetrate the center of the sample to a depth of 4·0 cm. Hardness was estimated by recording the peak height and/or the maximum penetration force (kg), during the compression.

Melting test

The effect of taro flour on the melting characteristics of fruit sorbet was compared with those of commercial stabilizers (CMC, CG, LBG) by means of the TUC Cream Corn Meter (The United Co. Westminister, MD, USA). The temperature of the test room was maintained at 23·5°C. Each sorbet was positioned at the center of the cream corn meter and melting distance was measured every 10 min at the 8 points of the cream corn meter (calibrated in in) until the sorbet melted completely.

Data were subject to analysis of variance and Duncan's multiple range test (Puri & Mullen, 1980).

RESULTS AND DISCUSSION

Viscosity

The results of viscosity tests on the tropical fruit–sorbet mixes are summarized in Table 3. From these data, it is clear that the viscosity of

TABLE 3
Comparisons of Viscosity and Hardness of Different Fruit Sorbet Mixes

Sorbet mixes	Stabilizer			
	Locust bean gum	Carrageenan	Carboxymethyl cellulose	Taro
		Viscosity[a]		
Guava sorbet	12·08 ± 0·25*	12·98 ± 0·23**	12·45 ± 0·25***	12·93 ± 0·26**
Papaya sorbet	13·41 ± 0·21*	12·36 ± 0·26**	12·43 ± 0·22**	13·03 ± 0·24*
Pineapple sorbet	12·22 ± 0·23*	12·97 ± 0·25**	12·07 ± 0·24*	14·98 ± 0·25*,**
Passion fruit sorbet	15·27 ± 0·26*	14·68 ± 0·24**,***	14·43 ± 0·27***	14·98 ± 0·25*,**
		Hardness[b]		
Guava sorbet	34·96*	46·76**	40·86***	44·04**,***
Papaya sorbet	61·74*	40·86**	40·86**	49·94**
Pineapple sorbet	39·04*	48·12**	35·41*	50·85**
Passion fruit sorbet	78·09*	63·56**,***	56·75***,****	72·64*,**

[a] Viscosity expressed in seconds of flow time through a vertical 10 ml pipette (i.d. 0·78 cm, tip opening 1 mm).
[b] Hardness as measured by Instron Universal Machine, Model 1102 with 0·085 cm diameter Magness-Taylor probe, expressed in kg.
Means of triplicates followed by same superscript within rows are not significantly different ($p \geq 0·05$) according to Duncan's multiple range test.

taro–used sorbet mixes was quite comparable to the other stabilizer-used sorbets. For papaya and passion fruit sorbet, the effect of taro powder on the viscosity of sorbet mix was not significantly different ($p < 0{\cdot}05$) from the locust bean gum. And in the case of papaya and pineapple sorbets, it was not significantly different ($p \leq 0{\cdot}05$) from CMC in all fruit sorbets. The viscosities of papaya and passion fruit sorbet mixes were slightly higher than the other fruit sorbet mixes. From the viscosity studies of several sorbet mixes, it was shown that the effect of taro powder on viscosity was almost the same, or slightly higher than, those of commercial frozen dessert stabilizer when its percent use in the mix was about 2·5%.

Hardness

The effects of four stabilizers on the hardness of fruit sorbets are compared in Table 3. The hardness values of sorbets containing taro were not significantly different ($p \geq 0{\cdot}05$) from those of sorbets containing carrageenan gum and carboxymethylcellulose in guava and papaya flavors. For pineapple sorbet, no significant differences in hardness ($p \geq 0{\cdot}05$) were found between sorbets containing taro and carrageenan gum. There were also no significant differences ($p \geq 0{\cdot}05$) in hardness between passion fruit sorbets containing taro and locust bean gum/carrageenan gum. Based on these observations, it is clear that precooked taro flour can replace some of the commercial stabilizers in various fruit sorbets without significant differences in hardness of the products.

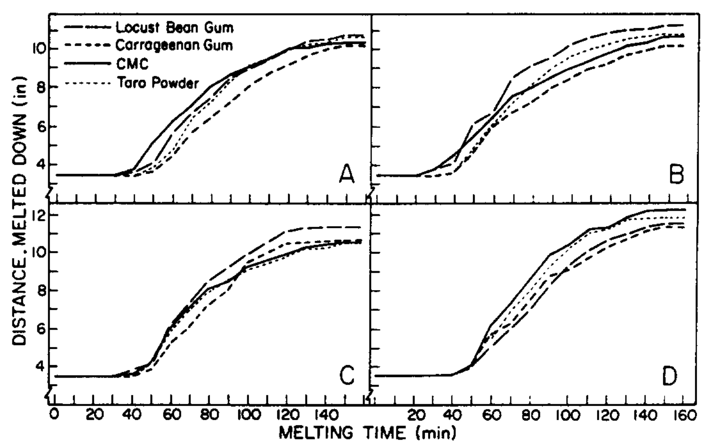

Fig. 1. Melting characteristics of various sorbets. A, guava sorbet; B, papaya sorbet; C, pineapple sorbet; D, passion fruit sorbet.

Melting characteristic

The stabilization effect of taro flour on the melting quality of tropical fruit sorbet in comparison with three different commercial stabilizers is shown in Fig. 1. Like the other sorbets containing commercial stabilizers, sorbets stabilized with 2·5% taro flour started to melt in 40 min to 50 min and melted completely in 150 min to 160 min after their removal from the freezer. With taro flour as stabilizer in fruit sorbet, fruit pulp separation was apparently inhibited when the sorbet was melted whereas fruit pulp separation was obvious in fruit sorbets using commercial stabilizer. This may be due to the higher total solids content in sorbets containing taro flour as compared to the other fruit sorbets. The stabilization effects of taro flour on the melting rate and the physical defects of sorbets, such as fruit pulp separation, were advantageous as compared to that of commercial stabilizers.

CONCLUSION

The functional properties of precooked taro flour in tropical fruit sorbet have been demonstrated. It can replace commercial gums in sorbet and can be produced from a common food crop in Hawaii and other tropical areas very simply without going through the extraction and purification steps like other commercial food gums/stabilizers. The use of precooked taro flour in similar or other products should be further explored. Better understanding of the functional and sensory properties of precooked taro flour may lead to the availability of a new stabilizer for the food industry.

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