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Full Length Research Paper

Effect of food binders on the textual and sensory characteristics of ice cream

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Ice cream was produced using local food binders namely: *Afzelia africana, Deuterium microcapum* and *Taro tuber* to find a suitable replacer for carboxylmethyl-celleuose (CMC). Results showed that, though viscosity, efflux time and foam stability increased with increase in *A. africana, D. microcapum* and *T. tuber* local food binder concentrations, they were significantly ($p < 0.05$) lower than CMC. The meltdown and overrun on the other hand decreased with increase in local food binder concentration. At 0.7% concentration, *D. microcarpum* had the same value with CMC. The pH of samples produced with the local binders did not differ statistically from CMC. Sensory evaluation results showed that sensory attributes generally improved with increased in concentration of *A. africana, D. microcapum* and *T. tuber*. On the basis of the textural and sensory characteristics of the local binders studied, *D. microcarpum* at 0.7% concentration was found to be the best local food binder to replace CMC in ice cream.

Key words: Ice cream, CMC, local food binders, texture, sensory characteristics.

INTRODUCTION

Ice cream is a complex system consisting of air dispersed as small cells in the partially frozen continuous phase. The continuous aqueous phase contains fats, milk solid non fats (msnfs) and stabilizers in colloidal solution (Anon, 1976). An important component of ice cream is the stabilizer. Stabilizers are group of ingredients (usually polysaccharides), commonly used in ice cream formulation. They perform several functions in ice cream such as increasing the viscosity of the continuous phase, and thereby contributing to the eating characteristics such as body and creaminess. Stabilizers regulate the development of crystals; promote the nucleation rate but retard linear growth rate (Muhr et al., 1986). As a result, a structure of many small ice crystals is obtained giving a smooth texture.

The first stabilizer to come into general use in ice cream was gelatin. Today a number of polysaccharide stabilizers have become available, and each with somewhat distinctive properties. These include sodium carboxylmethyl-celleuose (CMC), micro crystalline cellulose, carragreenan, xanthan gum among others (Larson and Friberg, 1990).

Available locally are many other stabilizers peculiar in various geographical locations. These stabilizers also known as local food binders are mainly tuber starches and leguminous seed powder used in traditional soup and broths as thickening agent. They are usually utilized in their native form. They include starch from *A. africana, Brachystegia eurycoma, D. microcapun, Mucana flagellipse* and *Glycin max*. From pre-historic times, these binders have been used successfully in traditional food system to increase viscosity, prevent water separation and improve body texture and flavour properties sought after in modern food stabilizers. As a result, CMC has become exorbitant in contrast to the local food binders which are commonly available, low priced, less demanded and poorly utilized.

This research therefore seeks to investigate the performance of three different local food binders namely *A. africana, D. microcarpum* and *T. tuber* starch in ice cream manufacture and to adopt textural and sensory analyses to determine a suitable replacer for CMC.

MATERIALS AND METHODS

Materials

A. africana, D. microcapun and *T. tuber* starch were brought from

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the local market in Makurdi, Benue State. Laboratory materials included metering device, pH meter, 1500 um sieve, thermometer, blender, 100 ml cup, beaker, stainless steel screen, Brookfield viscometer cone-shaped funnel, oven and CMC.

Ice cream production

Ice cream was produced according to the procedure described by Hui et al. (2004) with slight modification. Each mix consisted of 60% water, 10% msnf, 16% sucrose, 12.5% fats, 0.5% emulsifier and the local food binders in varied percentages (0.3 to 0.7%) and CMC at 0.5% as control.

Mix viscosity

Triplicate measurements of the viscosities of the mix were taken after 12 h aging at refrigerated temperature of 4 ± 1°C. Viscosities were measured at 6 ± 2°C using Brookfield viscometer (model LV8).

Melting resistance

Melting resistance was evaluated in triplicate according to Huse et al. (1984) with modifications. Blocks of ice cream (100 ml) at about -14 ± 4°C were placed on a stainless steel screen with aperture of 5 mm diameter, located on top of a breaker. The initial weight of the ice block (w_1) and the final weight (w_2) were taken after 45 min at room temperature. The % ice cream melted was calculated using the following equation:

$$\% \text{ Ice cream melted} = [(w_1-w_2)/ w_1] \times 100 \qquad (1)$$

pH measurement

The pH of the ice cream mix after aging was measured electrometrically using pH meter (model 152R).

Efflux time

Efflux time was determined as described by Hui (2004). The aged ice cream was stirred with a small plastic spoon for 10 s. A cone shaped funnel (550 ml) was filled with ice cream mix at 6 ± 2°C. The time necessary for the mix to flow freely from the upper mark to the lower mark of the funnel is the efflux time. Triplicate measurements were taken for each sample.

Overrun

Overrun was estimated in triplicate, using a standard 100 ml cup according to the method described by Hui et al. (2004). The percentage overrun which is the added air to the product was determined as: % overrun = (net weight of cup mix - net weight of cup of ice cream) / net weight of cup of ice cream (Equation 2).

Foam stability

Foam stability was determined using the method described by Adejo and Oguntunde (1993) with little modification. 200 ml of the mix was blended for 2 min in a domestic blender. The mix was poured into 250 ml graduated cylinder, and the volume of foam produced was recorded as V_1. After 5 s, the final volume (V_2) of the foam was measured and the % foam stability expressed as in equation 3: Foam stability = [(initial volume of foam - final volume of foam)/initial volume of foam] x 100.

Sensory analysis

Ten semi-trained panelists evaluated the sample after 24 h of refrigeration storage. The samples were left to attain a temperature of 8±2°C before evaluating for iciness, gumminess and creaminess on a ten point hedonic scale (0 absent; 1 extremely low; 2 very low; 3 moderately low; 4 slightly low; 5 neither nor low; 6 slightly high; 7 moderately high; 8 very high; 9 extremely high; 10 intense) or (0 absent; 10 intense) according to Huse et al. (1984).

RESULTS AND DISCUSSION

Effect of concentration on viscosity and efflux time

When 0.5% CMC was used as control, the ice cream viscosity was 48.940 ± 0.006 cP (Table 1), the maximum achievable. This differed significantly ($p \leq 0.05$) from the viscosity values obtained with the local food binders. The viscosity of *A. africana* and *D. microcarpum* ranked more closely to the control sample except at 0.3% where the viscosity of *A. africana* decreased significantly ($p \leq 0.05$) to 42.230 ± 0.013 cP. The general trend was increased in viscosity of ice cream with increase in local food binder concentration. This agrees with Larson and Friberg (1990), who reported that stabilizers primarily increase mix viscosity. *T. tuber* starch had lowest recorded viscosity.

The efflux time of 1619.60 ± 0.45 s was achieved with the control sample which was significantly ($p<0.05$) higher than the highest values obtained for the local binders (*A. Africana,* 1403.60 ± 8.20; *D. microcarpum,* 1249.30 ± 21.23; *T. tuber* starch 255.66 ± 6.02 s). Efflux time followed that same trend with viscosity, apparently because it depends on viscosity. The results confirm those of Hellinga et al. (1986).

Effect of concentration on the melting resistance and overrun

As shown in Table 1, the weight of melted ice cream of the control sample was 11.670. ± 0.471 of the initial weight. This value differed significantly ($p < 0.05$) from the local binders at all concentrations studied. The melting resistance of *D. microcarpum* at 0.7% ranked more closely to CMC, while *T. tuber* starch at 0.3% exhibited the most inferior effect on the melting resistance as it deviated more from CMC. In general, meltdown resistance of the ice cream improved significantly ($p < 0.05$) as concentration of the local food binders increases from 0.3 to 0.7%. These findings were in agreement with White et al. (1978); Guy (1980) and Huse et al. (1984).

The ice cream showed overrun of 21.00 ± 0.00% for the control (Table 1). When *A. africana, D. microcapun*

Table 1. Effect of local food binders on the mix viscosity, melting resistance, pH, efflux time, overrun and foam stability of ice cream.

Binder	Concentration (%)	Mix viscosity	Melting resistance	pH	Efflux time	Overrun	Foam stability
Afzelia african	0.3	42.230±0.01[e]	44.000±1.63[a]	6.440±0.03[a]	300.00±4.10[a]	23.33±0.47[ab]	70.00±0.00[ab]
	0.5	43.330±0.014[bed]	23.000±0.82[a]	6.480±0.08[a]	898.30±6.24[a]	21.06±1.21[c]	70.00±0.87[bc]
	0.7	43.520±0.01[bc]	18.000±1.29[be]	6.470±0.08[a]	1403.60±8.20[e]	20.33±1.25[e]	71.00±0.00[ac]
Deuterium mirocarpum	0.3	43.180±48[ed]	32.330±1.25[f]	6.450±0.08[a]	278.00±5.89[ab]	25.00±09[ab]	70.00±0.00[be]
	0.5	43.400±0.06[bed]	19.000±1.29[be]	6.460±0.01[a]	701.00±2.94[h]	21.00±0.00[e]	70.00 ±0.00[be]
	0.7	43.830±0.22[b]	11.66o±0.96[d]	6.470±0.04[a]	1249.30±21.23[f]	21.00±0.82[e]	70.67±0.47[b]
Taro tuber	0.3	39.01±0.005[f]	67.660±0.47[e]	6.460.01[a]	130.00±3.26[j]	25.66±0.46[a]	68.67±47[dc]
	0.5	39.460±0.08[f]	44.000±0.82[a]	6.470±0.01[a]	197.30±7.59[i]	21.33±0.47[c]	69.30±0.47[dc]
	0.7	39.480±0.08[f]	19.670±0.47[b]	6.480±0.01[a]	255.66±6.02[c]	21.00±1.41[c]	69.30±0.47[dc]
CMC (control)	0.5	48.940±0.01[a]	11.670±0.471[d]	6.460±0.00[a]	1619.60±0.45[d]	21.00±0.00[c]	72.30±0,47[a]

Values are in mean ± standard deviation. Values in the same column carrying different superscripts are significantly different ($p > 0.05$).

and *T. tuber* starch were used, the overrun varied between 20 - 25%. The result contrasted by over 80% the value given by Hui et al. (2004). This could be attributed to the fact that a home freezer was used instead of the usual standard scrapped surface heat exchanger. This may have affected drastically the amount of air incorporated into the frozen mix. The overall trend was a decrease in overrun as the concentration of local food binders increased from 0.3 to 0.7%. There was no significant difference ($p>0.05$) between the overrun of the control sample and that of *A. Africana, D. micocarpun* and *T. tuber* starch at 0.3, 0.5 and 0.7%.

Effect of concentration on the pH and foam stability

Table 1 contains data on ice cream mix. The pH including that of the control sample ranged from 6.440 ± 0.003 to 6.480 ± 0.008. The local food binder at all concentrations had no significant ($p >$ 0.05) effect on the mix pH, confirming the report of Tonna (1990) that the concentration or kind of stabilizer has no effect on the pH of ice cream mix. There was increase in the pH as the concentration of local binders increased from 0.3 to 0.7%. The increase was not significant ($p>0.05$) and was attributed to the fact that as concentration of local food binders increases, its inhibition effects on lactic acid bacterial increase accounting for a reduced acidity. This agreed with our previous report of pH 6.6 to 6.7 for pasteurized yoghurt, a value that can only be altered by a great deal of bacterial souring (Alakali et al., 2008).

The control sample gave the highest foam stability of 72.30 ± 0.47% which deferred significantly ($p \leq 0.05$) from the values obtained with the rest of the local food binders tested. All the local binders used performed optimally as their stabilizing effect were above 69% at the various concentrations.

In general, the foam stability of the mix was nearly unaffected as the local binders concentration varied between 0.3 to 0.7%, although it increased slightly with concentration, it was statistically not significant {p≥0.05}. This is attributed to a heavy and soggy ice cream which allows low whipability and a high stability that tends to remain relatively invariable (Larson and Friberg, 1990).

Effect of local binders' concentration on sensory properties of ice cream

Mean scores of iciness is presented in Table 2. Iciness of the control sample was 8.60 ± 0.49. This value was also shared by *A. africana* at 0.3% and *T. tuber* starch at 0.7%. Iciness was highly felt in all the samples at various concentrations. The iciness of *A. africana* increased from 8.20 ±0.24 to 8.60 ±0.36 when concentrations increased from 0.3 to 0.7%. At these concentrations, the iciness of *D. microcorpum* decreased from 8.50 ± 0.24 to 5.40 ±0.49 and that of *T. tuber* starch increased from 8.50 ± 0.96 to 5.30 ± 0.46. Generally there was no significant difference (p 0.05) as the concentration of stabilizers increased. Iciness high

Table 2. Effect of local binder on the iciness, creaminess and gumminess of ice cream mix.

Binder	Concentration (%)	Iciness	Gumminess	Creaminess
Afzelia africana	0.3	8.20±0.36[a]	5.20± 0.40[a]	6.40±0.49[cd]
	0.5	8.30±0.41[a]	5.50 ±1.58[a]	6.80.0.40[abc]
	0.7	8.60 ±0.24[a]	5.60 ±0.64[a]	6.90±0.30[abc]
D. Microcarpun	0.3	8.50 ± 0.24[a]	5.40 ±0.49[a]	6.20±0.40[dc]
	0.5	8.40 ± 0.49[a]	5.40 ±0.49	6.70±0.45[abc]
	0.7	8.30 ± 046[a]	5.40 ±0.49[a]	7.1± 0.30[ab]
Taro tuber	0.3	8.50 ±0.96[a]	5.20 ±0.64[a]	6.30±0.45[cd]
	0.5	8.50 ±0.50[a]	5.30 ±0.46[a]	6.60±0.48[bcd]
	0.7	8.60 ±0.49[a]	5.30 ±0.46[a]	6.80± 0.40[abc]
CMC (Control)	0.5	8.60 ±0.49[a]	5.70 ± 0.90[a]	7.20 ±0.40[a]

Values are mean ± standard deviation. Values in the same columns carrying different superscript are significantly different ($p < 0.05$).

scores were not similar to those reported by Huse et al. (1984).

The gumminess of the control was 5.70 ± 0.90 (Table 2). The gumminess of *A. africana ranged* from 5.20 ± 0.40 to 5.60 ± 0.64 when the concentration increased from 0.3 to 0.7%. At these concentrations gumminess of *D. microcarpum* was constant at 5.40 ± 0.49, and that of *T. tuber* starch decreased from 5.70 ± 0.64 to 5.30 ± 0.46. There was no significant difference ($p > 0.05$) in the creaminess of the control and the other samples (Table 2). The creaminess of control sample was higher than that of the local stabilizers tested. Creaminess generally increased with increased local binder's concentration. *D. microcarpum* at 0.7% impacted the best creaminess on the ice cream mix.

Conclusion

Foam stability overrun, and pH of the control did not differ significantly ($p > 0.05$) from that of the local food binders. There was significant difference in the mix viscosity, efflux time, and melting resistance of the control sample compared with the local food binders. *D. microcarpum* gave the best mix viscosity, melting resistance and overrun. *A. africana* gave the best pH, efflux time and foam stability. Sensory properties showed that *T. tuber* starch gave the best creaminess and gumminess. In general, *D. microcopum* at 0.7% concentration is recommended as the best replacer of CMC in ice cream production.

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