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Carboxymethyl starch: an extrusion aid

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Carboxymethyl starch (CMS) prepared from corn and waxy small sized amaranth starch were tested as an extrusion aid in ready-to-eat extruded snack prepared from semolina. The CMS was used at 0.25–1.0% and had a degree of substitution (DS) ranging from 0.1–0.2. The extruded products were analysed for bulk density, moisture, expansion ratio, and texture analysis using Stevens LFRA Texture Analyser. Waxy amaranth starch was found to be slightly better than corn starch, when samples containing CMS with identical DS used at the same level were compared. Copyright © 1996 Elsevier Science Ltd

INTRODUCTION

Carboxymethyl derivatives of gums as well as modified starches have been reported to be useful as additives in food extrusion (Keller, 1982; Meuser *et al.*, 1992; Colona *et al.*, 1989). The present work was planned to explore the suitability of carboxymethyl starch (CMS) as an extrusion aid. Since the properties of starch depend on amylose/amylopectin ratio and the size/shape of the starch granule, CMS preparted from conventional corn starch and waxy starch from *Amaranthus paniculatas* having an extremely tiny granule size of 1–2μm were compared.

MATERIALS AND METHODS

Wheat semolina was procured from a local market of Bombay city. CMS having degree of substitution (DS) 0.10, 0.15 and 0.20 were prepared from corn and *A. paniculatas* in the laboratory under previously optimized conditions. The preparation of sodium CMS from corn and waxy amaranth starch was carried out under alkaline conditions using sodium hydroxide (dissolved in water) in isopropyl alcohol as the solvent medium and using sodium monochloroacetate as the carboxymethylating agent. The reaction was carried out for a definite time period at the previously optimised

Table 1. Conditions used for the preparation of CMS from corn and amaranth starch having a DS 0.10, 0.15 and 0.20

	DS of CMS		
	0.10	0.15	0.20
Corn starch:			
Amount of starch (g)	10	10	15
Amount of NaOH (g)	9	9	13.5
Amount of sodium monochloroacetate (g)	10	10	15
Volume of isopropanol medium (ml)	200	150	180
Volume of water added to the medium through NaOH solution (ml)	50	30	35
Time of reaction (min)	90	90	90
Temperature of the reaction (°C)	50	55	65
Amaranth starch:			
Amount of starch (g)	12	12	15
Amount of NaOH (g)	9.6	10.8	16.5
Amount of sodium monochloroacetate (g)	12	12	22.5
Volume of isopropanol medium (ml)	72	72	90
Volume of water added to the medium through NaOH solution (ml)	18	18	22.5
Time of reaction (min)	90	90	90
Temperature of the reaction (°C)	Room temp. (30± 2°C)	Room temp. (30± 2°C)	Room temp. (30± 2°C)

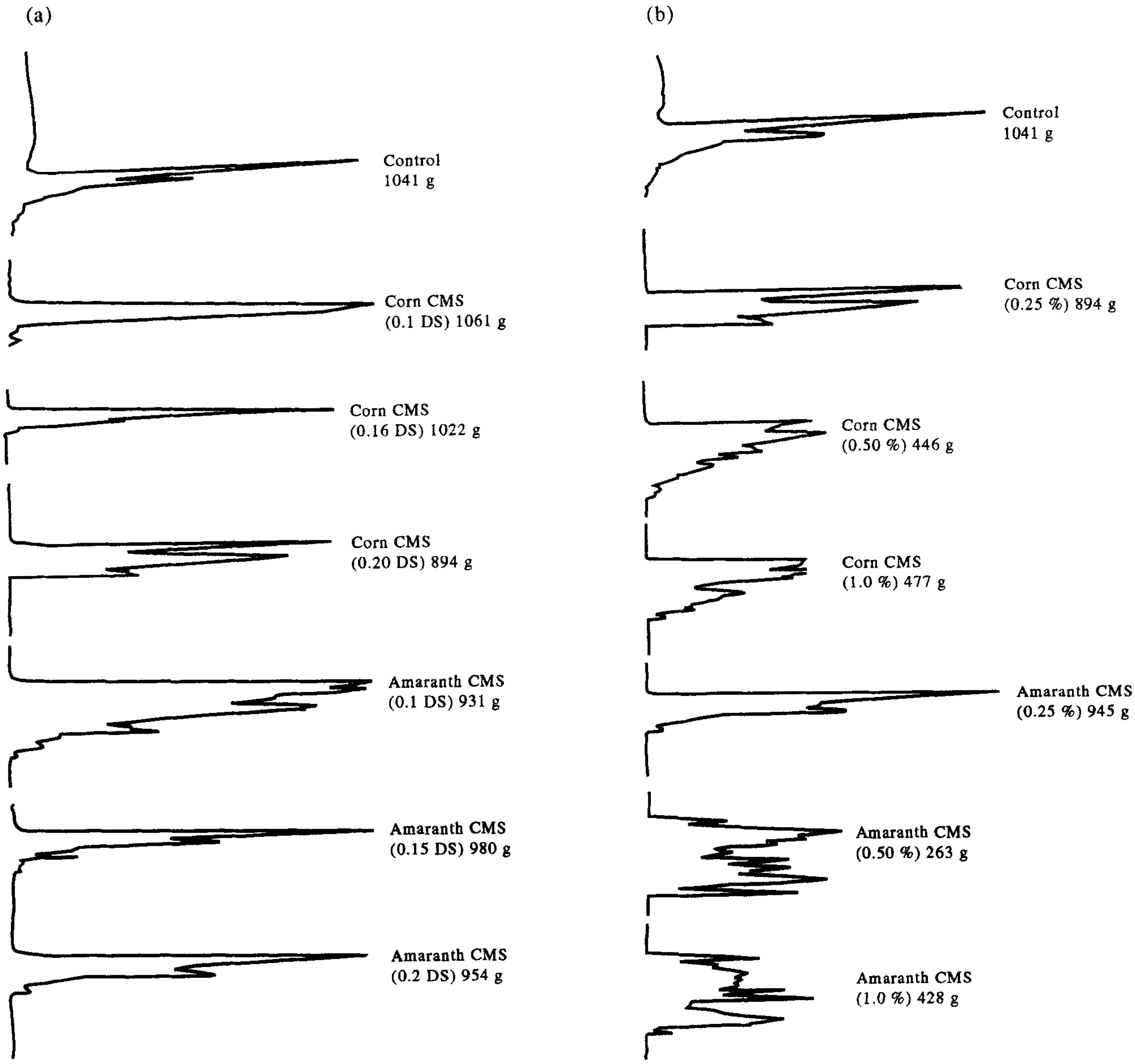

Fig. 1. Texture profile of extrudates containing 0.25% CMS from corn and amaranth starch of varying DS.

temperature after which the CMS was isolated by precipitating in 95% alcohol. It was subsequently filtered and washed with 80% ethanol to make it alkali free, reprecipitated with 95% ethanol and then dried at 85°C for a suitable time period to get a dry powdered product. All the parameters of this preparation were optimised (Bhattacharyya *et al.*, 1996). In particular, sodium CMS from corn and amaranth starch of DS 0.10, 0.15 and 0.20 were prepared in the laboratory as shown in Table 1.

Semolina was extruded using a Brabender single screw extruder without CMS (control) and with CMS of different DS added at 0.25, 0.50 and 1.0% to prepare a ready-to-eat (RTE) product. Before extrusion, the moisture content of the semolina was adjusted to 15%. It was fed to the extruder under the following conditions:

Temperature of the firstst zone of extruder barrel (feed section)	150°C
Temperature of the second zone (compression section)	150°C
Temperature of the third zone (metering section)	180°C
Die diameter	4 mm
Screw speed	200 rpm

The extruded products were analysed for moisture (AOAC, 1984), bulk density, expansion ratio and texture profile. The bulk density was found by measuring the volume and weight of several cylindrical shaped pieces of the material, selected at random and taking the

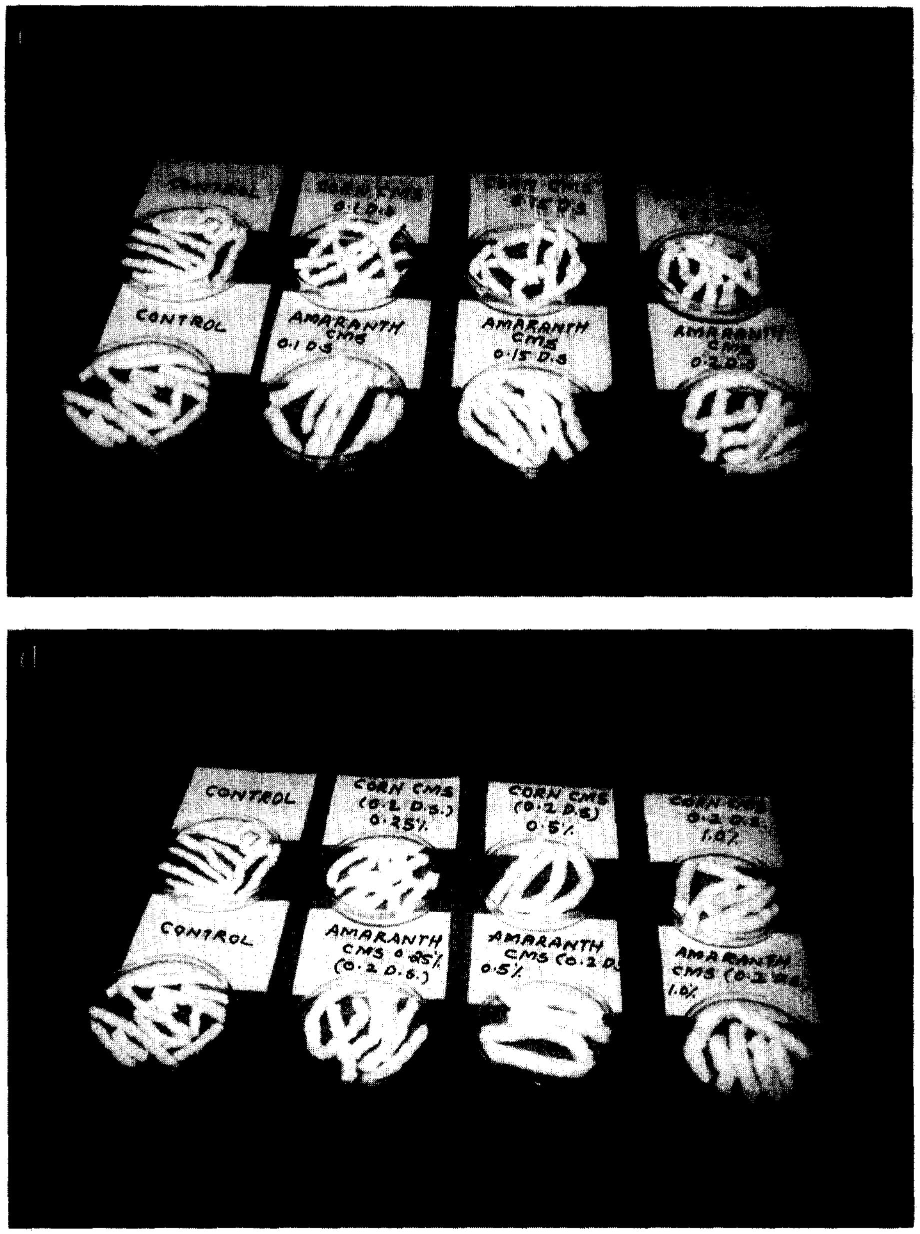

Fig. 2. (a) Texture profile of extrudates containing CMS from corn and amaranth starch at 0.25% of varying DS. (b) Texture of profile of extrudates containing CMS of DS 0.2 from corn and amaranth starch at varying levels.

Table 2. Analysis of the RTE extruded products[a]

Product type	Moisture content (%)	Bulk density g/cm^3	Texture profile expressed in load (g)
Control[b]	8.48±0.13	3.28±0.03	1041±51
Corn CMS of DS 0.1 at 0.25%	9.65±0.03	3.26±0.14	1061±32
Corn CMS of DS 0.15 at 0.25%	9.65±0.05	4.32±0.2	1022±43
Corn CMS of DS 0.20 at 0.25%	10.05±0.05	3.94±0.5	894±24
Corn CMS of DS 0.20 at 0.5%	8.03±0.01	1.51±0.10	446±32
Corn CMS of DS 0.20 at 1.0%	8.25±0.03	1.57±0.13	477±45
Amaranth CMS of DS 0.10 at 0.25%	7.95±0.16	1.75±0.08	931±63
Amaranth CMS of DS 0.15 at 0.25%	9.47±0.10	3.62±0.50	980±42
Amaranth CMS of DS 0.20 at 0.25%	9.27±0.04	3.05±0.03	954±38
Amaranth CMS of DS 0.20 at 0.50%	8.30±0.10	1.74±0.18	263±40
Amaranth CMS of DS 0.20 at 1.0%	7.99±0.05	1.75±0.02	428±56

[a]All results are mean ± SD of three or more individual data.
[b]Without CMS.

mean. Expansion ratio was calculated as the ratio of diameter of the extruded samples to that of the extruder die. Texture of the product was determined using Steven LFRA Texture Analyser. Needle probe TA 8 at a speed of 2 mm and 10 mm depth of penetration in the normal mode was used for texture evaluation. The samples were also evaluated organoleptically using a panel of five members on a 10 point hedonic scale (Piggott, 1984) where 8 points or more = excellent, 6–7 points = good, 4–5 points = fair, 3–4 points = poor and 0–3 points = unacceptable.

RESULTS AND DISCUSSION

The moisture content, bulk density and texture profile expressed in load (g) required to penetrate the product and come out, of the control and all the experimental samples are as shown in Table 1. It can be observed that the moisture content of the samples did not vary significantly. Samples containing CMS of lower DS at a lower level were harder and rigid which is also clearly evident from density and load profiles.

Expansion of the product and fluffiness as well as crispness was observed with CMS of DS 0.2 added at the 0.5% level. This is also evident from bulk density and load values. A low bulk density indicates a lighter product and a lower load value indicates a softer product with good porous structure and good crispness. This can be seen from graphs obtained during texture analysis (Fig. 1a and b). These observations were true for CMS obtained from both corn and amaranth starches.

Expansion ratio and organoleptic properties of the semolina based extruded products before and after addition of CMS are as given in Table 2. A product with good puffing and which is organoleptically sound can be obtained by CMS addition and the best results are obtained with CMS of DS 0.2 added at the 0.5% level. These products had good texture, crispness and mouthfeel. Products with amaranth CMS at the same level were more brittle or softer and with better mouthfeel than those of corn starch.

No comparable reports are available for confirming these results. However, it can be hypothesised that the hydrophilic nature of CMS may give a plasticising and stability effect to the dough, so that its evaporation rate can be changed (Huber, 1991). Retention of moisture probably assists better expansion of the product during extrusion. This expansion ultimatelty enhances textural properties of the extruded products (Fig. 2a and b). In the case of products containing CMS from amaranth, it was observed that products with more fluffiness, fragile structure and better mouthfeel were obtained as compared to corn CMS. This can be explained on the basis of a report (Harper, 1981) that suggests amylopectin to produce fluffier extrudates than amylose. Amaranth starch is known to contain > 98% amylopectin (Singhal & Kulkarni, 1988).

These preliminary findings suggest CMS as an extrusion aid. The results are encouraging enough to warrant further studies to confirm this role of CMS as established for the first time from the present work.

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