Effect of Popping on the Properties of Some Millet Starches

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Starches were isolated from popped bajra (Pearl millet), ragi (Finger millet) and Navane (Foxtail millet). Popping resulted in complete loss of birefringence characteristics of starch granules, increased solubility in DMSO, low cold paste and setback viscosity and lower relative viscosity in KOH. Popped starches in comparison to native starches exhibited higher susceptibility to *in vitro* enzymatic digestibility.

Der Einfluß des Puffens auf die Eigenschaften einiger Hirsestärken. Die Stärken aus gepufftem Bajra (Perl-Hirse), Ragi (Finger-Hirse) und Navane (Fuchsschwanz-Hirse) wurden isoliert. Das Puffen führte zu einem vollständigen Verlust der Doppelbrechungseigenschaften der Stärkekörner, erhöhte die Löslichkeit in DMSO und führte zu niedrigerer Retrogradationsviskosität sowie niedrigerer relativer Viskosität in KOH. Die gepufften Stärken zeigten im Vergleich zu den nativen Stärken höhere Empfindlichkeit gegenüber dem enzymatischen *in vitro*-Abbau.

1 Introduction

Popping of cereals is a well known traditional method of processing. It is a simple and least expensive method of preparing ready to consume cereal products. While popping of maize is popular all over the world [1], sorghum [2, 3], paddy and other minor millets are often popped in India and Africa since a long time [4]. The kernel is subjected to high temperature for a short time during popping and this brings about several physicochemical changes in its major component starch. Extensive literature is available on the physico-chemical characteristics of native millet starches [5–12], while information on processed millet starches is scanty [13–16]. This communication describes the results of a study of the effect of popping on the physicochemical properties and *in vitro* amylase digestibility of starches from a few millets.

2 Materials

Bajra (*Pennisetum typhodium,* Pearl millet), ragi (*Eleusine coracana,* Finger millet), and Navane (*Setaria italica,* Foxtail millet) were obtained from different millet breeding stations.

3 Methods

Popping

The grains were moistened to 19% moisture level and conditioned in a closed tin for 4 h. Popping was done at 250°C on a sand medium [4]. Fully expanded kernels were sorted out and used for starch isolation.

Starch Isolation

Popped kernels, soaked in water for 6 h were macerated in a waring blendor. Starches were isolated from the mash as reported earlier [12].

Scanning Electron Microscopic Examination

Thin sections of popped kernels were mounted on brass stubs using double sided adhesive tape and vacuum coated with gold (200 Å). The samples were viewed in Hitachi Model S-450 Scanning Electron Microscope.

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Light Microscopy

Isolated starch suspensions in water were viewed in a Carl-Zeiss photomicroscope.

Viscosity Determination

The relative viscosity (η_v) of starch solutions (1.0%) prepared in 1-N KOH was determined in an Ostwald U-shaped Viscometer (using the equation $\eta_v = t_s/t_o$, where t_s and t_o are the flow time of starch solution and solvent, respectively).

In vitro Digestibility of Starches

Starch (100 mg) was incubatd with pancreatin in citrate-phosphate buffer (20 ml, pH 7.0). At 60, 120 and 180 min intervals, aliquots (5 ml) were withdrawn and added to alcohol (15 ml) and centrifuged. Supernatants were examined by the *Nelson-Somogyi* method [17].

Miscellaneous Methods

Swelling and solubility, estimation of amylose, pasting characteristics, solubility in dimethyl sulphoxide (DMSO), and gelatinization temperature range of starches were studied by the methods reported earlier [7].

4 Results and Discussion

Starches isolated from popped bajra, ragi and navane were obtained in 44, 35 and 42% yields, respectively. Since popping involved prior moistening (19% level) of millet grains followed by severe heat treatment it was expected that part of the starch granules would undergo gelatinization and as a consequence the starch recovery is impaired. This was indeed the case as evident from the comparatively low starch yield as well as low amylose content (Table 1).

The isolated starches showed no birefrengence characteristics typical of native starch granules. They stained with Congored indicating starch gelatinization [18]. Light micrographs of the isolated starch showed complete disruption of the granular matrix (Figs. 1a, b, c).

However, scanning electron micrographs of the thin sections of popped grains (before starch isolation) showed (Figs. 2a, b, c) several features: (1) granular matrix which still retained hexa/polygonal nature, (2) enormous swelling, and (3) complete disruption of granular matrix and imparting a flaky appearance.

In comparison to native millet starches, starches from popped millets showed slightly higher solubility/swelling power at pre-gelatinization temperatures. But the effect was more pronounced around 90°C (Table 1). This in part, may be attributed to swelling as a result of gelatinization of starch granules during popping. Similarly the solubility in DMSO of the popped millet starches was increased, nearly 90% solubility obtained within 48 h. On the other hand, the relative viscosity of popped starches was low in comparison to the native starches the respective values being bajra 3.19, 4.42; ragi 3.22, 4.49; and navane 3.01, 4.42.

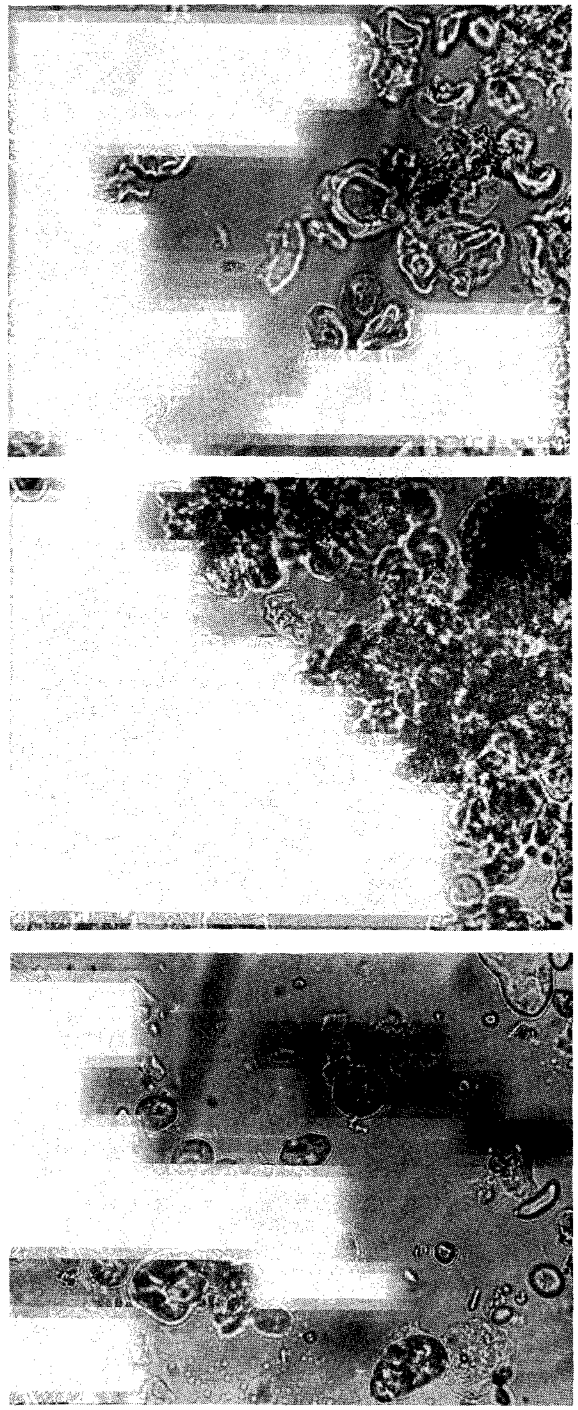

Figure 1. Photomicrographs of popped millet starches. (a) Bajra; (b) ragi; (c) navane.

Table 1.
Solubility (%)/Swelling Power (at 90°C) and Amylose Content of Native and Popped Millet Starches.

Millet	Native			Popped		
	Amylose	Solubility	Swelling power	Amylose	Solubility	Swelling power
Bajra	26.0	7.51	11.41	18.6	9.75	12.97
Ragi	29.5	7.03	10.31	18.5	10.94	11.41
Navane	24.4	7.00	11.65	19.7	9.00	12.80

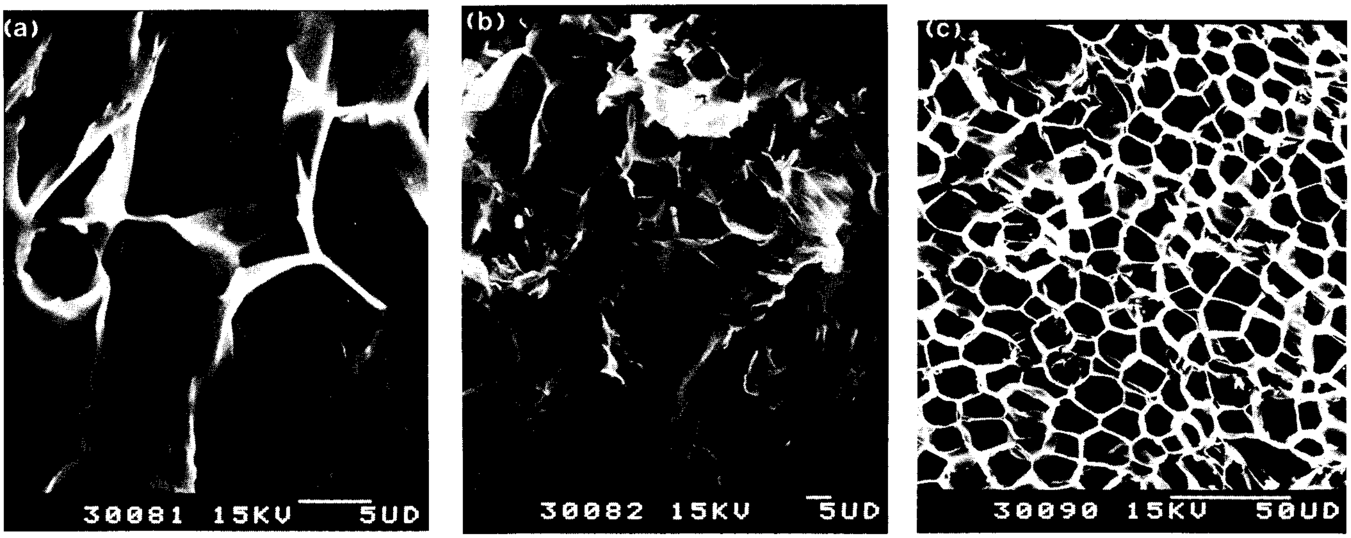

Figure 2. Electron micrographs of popped millet kernels. (a) Bajra; (b) ragi; (c) navane.

A similar trend was observed in Brabender amylograms of the popped millet starches (given only for bajra and ragi starches). Contrary to the native starches the peak as well as setback viscosity decreased as a result of breakdown of starch granules during popping which resulted in partial loss of amylose. It can be seen from the Figure 3 (given only for bajra and ragi), that the starch slurry had considerable cold paste viscosity (ragi 1 100 B. U. and bajra 950 B. U.). During setback, viscosity gain was negligible and it was much lower compared to native starch.

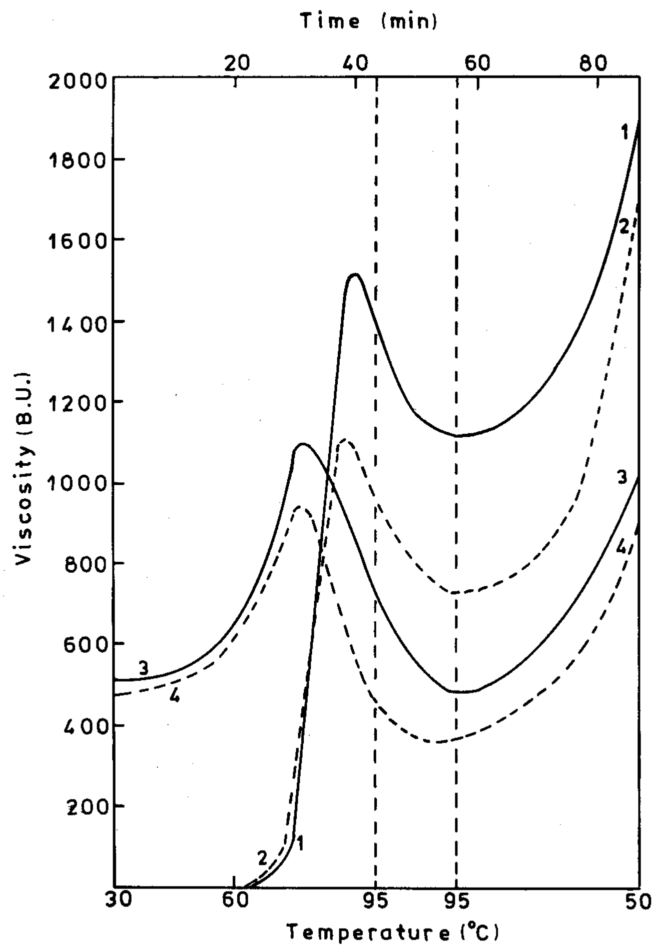

Figure 3. Brabender amylograms of native and popped millet starches. (1) Ragi starch (native); (2) bajra starch (native); (3) ragi starch (popped); (4) bajra starch (popped).

The pancreatic α-amylase digestibility of popped millet starches measured as the release of reducing sugars is represented in Table 2. A high enzymatic susceptibility was noticed, over 50% starch being hydrolyzed within 180 min. This can be taken advantage of in the preparation of some ready to consume food products.

Table 2.
In vitro Digestibility (%) of Native and Popped Millet Starches.

Millet	Native (Time in min)			Popped (Time in min)		
	60	120	180	60	120	180
Bajra	40.2	52.6	62.4	48.6	60.4	72.8
Ragi	43.4	54.0	66.0	52.6	62.4	74.2
Navane	26.0	33.6	46.8	31.4	43.2	52.4

However, comparatively popped navane was less digestible probably due to low degree of gelatinization during popping. In part this also depends on the grain (as well as starch) morphology. The presence of hard seed coat on navane grain may prevent effective heat transfer and thus resulting in only a partial gelatinization of starch.

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