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Influence of polysaccharide composition in foam stability of espresso coffee

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Abstract

In expresso coffee (EC) brew, persistent foam is of great importance as it is responsible for the visual acceptability of the drink and for trapping the volatilized aromas. The foam stability of EC is related to the amount and type of polysaccharides extracted from the roasted ground coffee, where they behave as viscosity improvers. This work relates the changes of the molecular weight of the polysaccharides present in the infusion caused by the roast that the coffees were submitted to and the foam stability of the resulting EC. The polymeric carbohydrates of each EC were precipitated with 55 and 75% ethanol solutions (Et55 and Et75, respectively). Fraction Et55, composed mainly of galactomannans, was fractionated by size-exclusion chromatography and two type of polymers were separated. The polymers that eluted with the void volume (2000 kDa) were inferred to be composed of polysaccharide and protein, possibly products of Maillard reactions caused by the roasting process. The molecular weight of the major fraction was estimated to average 70 kDa. The amount of material recovered with higher molecular weight gave a high correlation with the foam stability of EC. The results show that the amount of material of high molecular weight, in addition to the viscosity of the continuous phase, can also be responsible for the stabilization of the EC foam.

Keywords: Espresso coffee; Foam stability; Polysaccharides; Galactomannans; Degree of roast; Coffee

1. Introduction

Every day, more than 50 million cups of espresso coffee (EC) are consumed in the world. In EC brew, the persistent foam is of great importance as it is responsible for the visual acceptability of the drink. In addition, the building up of foam traps the volatilised aromas and doses their emission to the atmosphere (Illy and Viani, 1995). The foam stability of EC was shown to be related to the amount of polysaccharides extracted from the roasted ground coffee, where they behave as viscosity improvers (Nunes et al., 1997). The roast of the coffee significantly changes the structure of the polysaccharides present, conferring different functional properties to these polymers (Trugo, 1985). This work discusses the influence of the changes in molecular weight of the polysaccharides present in the infusion caused by the roast that the coffees were submitted to and the foam stability of the resulting EC.

2. Materials and methods

2.1. Espresso coffee preparation

The espresso coffee was prepared according to Nunes et al. (1997). The Uganda coffee beans were roasted at 200 ± 5°C and degassed during 2 days at room temperature. The degree of roast (DR) was quantified by the percentage lost in weight (%WL) of green coffee beans, on a dry basis. All the espresso coffee samples were prepared from 6.0 g of ground roasted coffee for a volume of 40 ml of EC using an espresso coffee machine. The filter holder was cooled for 10 min in water at room temperature before each experiment. The EC temperature was 63.5°C.

2.2. Foam stability determination and carbohydrate analysis

The foam stability (FS) was defined as the time (in seconds) that the liquid phase below the cream layer took to appear during cooling at room temperature, using a 50 ml beaker. The chemical analysis of the EC samples were prepared from a set of four EC. The samples were rapidly

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Table 1
Influence of the degree of roast (DR) on the foam stability (FS), total solids (TS), material insoluble in water (Ins. Res.) and the ethanol precipitated material (Et55 and Et75)[a]

DR (% WL)	FS	TS	Ins. Res.	Et55	Et75
3.1	8	72	78	40	75
5.7	45	85	100	62	92
7.6	100	96	74	100	98
9.5	28	98	75	79	67
15.5	33	100	65	63	100

[a]Values expressed as the relative percentage of the highest value.

cooled, concentrated under reduced pressure at 40°C, frozen, and freeze dried. The polymeric carbohydrates were precipitated with ethanol solutions (55 and 75% ethanol fractions) according to the procedure used by Coimbra et al. (1996) as described by Nunes et al. (1997). The component monosaccharides were released by Saeman hydrolysis (Selvendran et al., 1979) and analysed as their alditol acetates by gas–liquid chromatography (Blakeney et al., 1983; Harris et al., 1988).

2.3. Gel-filtration chromatography

Gel-filtration chromatography was performed on a column (40 × 2.6 cm) of Sephacryl S-400HR at a flow rate of 20 ml/h as described by Coimbra et al. (1995). Samples were dissolved in 0.5–1 ml 50 mM potassium phosphate buffer, pH 6.5, with 0.2 M NaCl. Fractions (2 ml) were collected and aliquots (20 μl) were assayed for carbohydrate by the phenol–sulphuric acid method (Dubois et al., 1956). To calibrate the column standard dextrans of 2000, 487, 266, and 72 kDa were used. The internal volume of the column was determined by elution of glucose.

3. Results and discussion

Table 1 shows the influence of the degree of roast (DR) in the EC parameters foam stability (FS), total solids (TS), material insoluble in water (Ins. Res.), material insoluble in 55% ethanol (Et55), and material insoluble in 75% ethanol (Et75). The EC studied shows a maximum FS for the DR of 7.6%. This value is clearly higher than the values determined for the other DR, a behaviour that was shown to be related to the amount of polysaccharides extracted to the EC (Nunes et al., 1997). Table 1 also shows that the amount of material present in fraction Et55 is also maximum for the DR of 7.6%. This fraction was shown to contain the majority of the EC galactomannans (Nunes et al., 1997). These polysaccharides are known to stabilise the foam by increasing the viscosity of the liquid phase. In order to evaluate the importance of the molecular weight of the espresso coffee galactomannans in the FS, these polymers were fractionated by size-exclusion chromatography. Fig. 1 shows the molecular weight profile of the polysaccharides present in the Et55 fraction for each DR. Two distinct carbohydrate fractions can be observed in each chromatogram. The molecular weight of the major fraction was estimated as 70 kDa. A slight decrease in the mean molecular weight of these polymers can be observed with increase of the DR, possibly caused by the roast. The chromatograms represented in Fig. 1 also show peaks that represent polymers that eluted with the void volume (2000 kDa). When the relative intensities of the two peaks in each chromatogram were compared, it was observed that there is an increase in the percentage of high molecular weight material (HMWN) and then, after DR 7.6% a further increase of the DR decreases the relative amount of this type of material

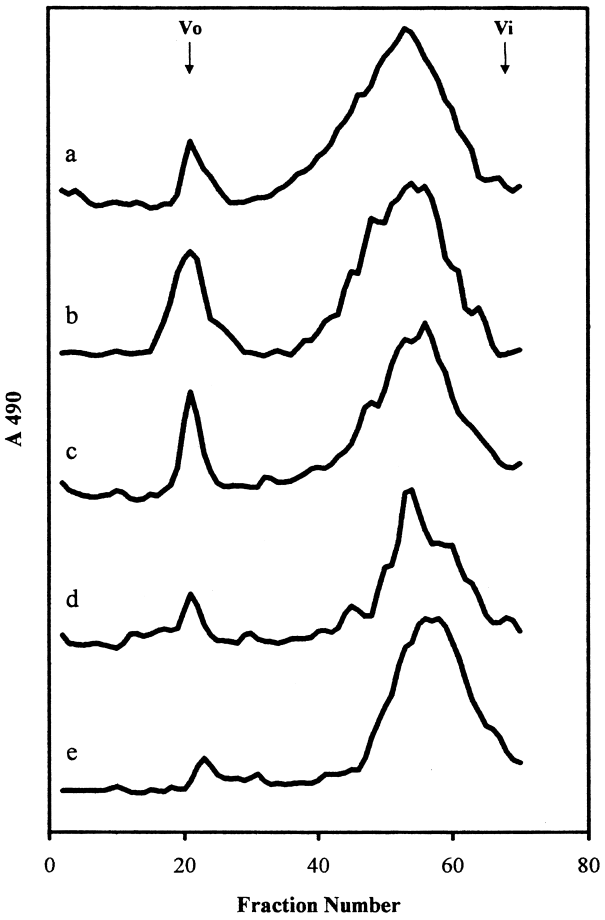

Fig. 1. Chromatography on Sephacryl S-400 HR of fractions Et55: (a) DR = 3.1%; (b) DR = 5.7%; (c) DR = 7.6%; (d) DR = 9.5%; (e) DR = 15.5%; Vo, void volume; Vi, included volume.

Table 2
Carbohydrate characteristics of the Et55 fraction as a function of the degree of roast (DR)

DR (%WL)	Total sugars (mg)	EC sugars (mol%)			% HMWC
		Ara	Man	Gal	
3.1	139	12.2	61.5	26.3	8.8
5.7	248	8.3	74.0	17.6	13.7
7.6	315	6.8	76.7	16.5	14.3
9.5	251	2.9	85.3	11.8	10.1
15.5	188	5.3	86.2	8.5	9.1

(Table 2). The presence of high molecular weight material may be due to complexes between polysaccharide, protein and phenolic compounds caused by the roasting process. The type of intermolecular linkages is under study in our laboratory. It is possible that these materials are products of Maillard reactions, as inferred by the brownish colour, and by the fact that it was reported to be impossible to isolate roasted coffee polysaccharides without a chlorite treatment (Thaler, 1979). The amount of this material of high molecular weight, although very small (0.3–0.9% of the total solids) gave a very good correlation with the foam stability of EC and seems to be an important factor to explain this parameter. This type of polysaccharide–protein complex appears to have rheological properties that should be explored in order to improve the parameter 'espresso coffee foam stability' (Hattori et al., 1997).

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