The effect of soluble fibre content of beet pulp on the in vitro alpha-amylolysis of a semi-synthetic meal

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THE EFFECT OF SOLUBLE FIBRE CONTENT OF BEET PULP ON THE *IN VITRO* ALPHA-AMYLOLYSIS OF A SEMI-SYNTHETIC MEAL

EFFET DE LA TENEUR EN FIBRES SOLUBLES DES PULPES DE BETTERAVE SUR L'ALPHA-AMYLOLYSE *IN VITRO* D'UN REPAS SEMI-SYNTHÉTIQUE

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SUMMARY

Sugar-beet pulps were treated by autoclaving and/or freeze-drying. Autoclaving increased the soluble/insoluble fibre ratio but freeze-drying had no effect. Sugar-beet pulps were mixed with a semi-synthetic diet simulating a human meal in order to introduce 6% total fibre content. The diets were incubated with a porcine pancreatic α-amylase for two hours. The initial *in vitro* hydrolysis pattern of the meal starch was changed by beet fibres. Increase in soluble fibre concentration by autoclaving did not reinforce this effect.

Key-words: *amylolysis, soluble fibres, sugar-beet pulps.*

RÉSUMÉ

Des pulpes de betterave sont soumises à des traitements d'autoclavage et/ou de lyophilisation. L'autoclavage augmente le rapport fibres solubles/insolubles, alors que la lyophilisation n'a pas d'effet. Les pulpes sont incorporées à un aliment simulant l'alimentation humaine à un taux de 6 % de fibres totales. Tous les aliments subissent l'action d'une α-amylase pancréatique de porc, pendant deux heures. La présence de fibres de betterave modifie l'hydrolyse *in vitro* initiale de l'amidon de l'aliment. L'augmentation du taux de fibres solubles par l'autoclavage ne renforce pas cet effet.

Mots clés : *amylolyse, fibres solubles, pulpes de betterave.*

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1 - INTRODUCTION

Numerous epidemiological or experimental studies on humans or animals have suggested that supplementation in dietary fibre has a beneficial effect on diabetes (ANDERSON *et al.*, 1987; SCHWARTZ *et al.*, 1988) and most of these studies emphasize the predominant effect of soluble fibres (SCHNEEMAN, 1987; SMITH, 1987). This result showed that it was worthwhile increasing the soluble fibre content of raw materials by technologic means in order to improve the effects on glycemia. Autoclaving has been shown to increase the soluble/insoluble fibre ratio of beet pulp (GUILLON, 1989). Beet pulp are an interesting potential source of nutritive fibre and are now commercially available in several countries as a "fibre additive" for human nutrition.

The purpose of the present study was to determine the importance of the soluble fraction of beet fibre in starch digestion. Indeed, the delay due to the digestion of starch in the human intestine is suggested to be a factor involved in the decrease in postprandial glycemia induced by fibre consumption (CHERBUT *et al.*, 1988; HAMBERG *et al.*, 1989). An *in vitro* α-amylolysis test simulating intestinal conditions was used in this study. CHAMP *et al.* (1988) observe that this *in vitro* α-amylolysis test is closely related to *in vivo* starch digestion in pigs fed with a guar gum diet. Furthermore this test gives a close prediction of the *in vivo* glycemic index (HOLM *et al.*, 1988).

2 - MATERIAL AND METHODS

Material

Dried beet pulp (SRD Laboratory, Compiegne, France) with a mean particle size of 570 µm were immersed in water and freeze-dried with or without prior autoclaving. Two autoclaving conditions were used: AI, 136°C at 2 bars, A2, 122°C at 1 bar.

Preparation and composition of the diets

Beet pulp fibre was incorporated (6% of total diet) in a semi-synthetic diet. This diet was composed of 65.3% mashed potatoes (Vico, Braine, France), 12.7% fish meal (Lorientaise des Produits de la Pêche, Lorient, France), 19% fat (maize oil (4%) and lard (15%)), and mineral and vitamin (3%) supplement. This diet, rich in fat and containing a source of cooked starch, was supposed to simulate human food.

Methods

α-amylolysis of 5 g (dry matter) of the diet was carried out with a porcine pancreatic α-amylase (Merck, ref. 16312) (280 U.I./g of starch) in a buffered medium of pH 7 (100 ml of phosphate buffer 0.005 M) during two hours at 37°C. Samples collected at times of 2, 5, 7, 10, 20, 40, 60, 90 and 120 minutes were homogenized in an ethanol 95°GL - pure acetic acid (100/1.5) (vol/vol) solution. The tubes were kept overnight at -20°C, and centrifuged for 20 minutes (9 000 *g* and 0°C). The supernatant contained the soluble dextrins liberated during the amylolysis.

Alcoholosoluble dextrins were determined using the orcinol-sulfuric acid method (TOLLIER and ROBIN, 1979). Total, soluble and insoluble fibres of the beet pulp were analyzed in accordance with PROSKY *et al.* (1988).

3 - RESULTS AND DISCUSSION

Chemical characterization of sugar beet pulp

The chemical composition of the pulp used has been studied by GUILLON (1989) and is given in table 1. The initial and treated pulp had close chemical composition. Beet pulp was rich in galacturonic acid, arabinose and glucose. This composition is consistant with the presence of pectins, arabinans and cellulose as main polymers.

Table 1

Chemical composition of untreated and treated sugar-beet pulp (% dry matter)

	Untreated	Freeze-drying	Autoclaving at 122°C	Autoclaving at 136°C
Prot (N x 6.5)	3.6	3.6	3.8	3.9
Ash	3.2	2.9	3.2	3.3
Gal. ac.	21.2	22.1	24.2	21.6
Rha	1.0	1.0	0.9	1.0
Ara	21.0	20.1	20.6	19.5
Xyl	1.4	1.4	1.4	1.4
Man	1.4	1.2	1.4	1.3
Gal	4.9	4.7	4.8	4.8
Glc	21.5	21.6	21.5	22.8
Methanol	3.9	3.9	nd	nd
Acetic acid	3.0	3.1	nd	nd

nd : Not determined.

Dietary fibre content (total, soluble and insoluble) is reported in table 2. The total beet pulp fibre content, used in the present study, was relatively high within the range reported for the beet pulp by MICHEL *et al.* (1988).

Table 2
Dietary fibre components of sugar-beet pulp before and after autoclaving (% dry matter)

	Dietary fibre		
	Insoluble	Soluble	Total
Untreated	79.0	15.4	94.4
Autoclaved at 122°C	52.5	25.9	78.3
Autoclaved at 136°C	48.9	29.7	78.5

Freeze-drying did not induce any variation in the total fibre content and in the ratio of soluble to insoluble fibre. This observation was foreseeable as no wet heat treatment was applied during the process. On the contrary, the total amount of fibre decreased (from 90 to 73%) during autoclaving. Similar results have been obtained by VARO *et al.* (1984). These authors concluded that analytical methods underestimated the fibre content. In the present study, this was probably due to the separation of soluble and insoluble fibre which excluded the oligosaccharides with low degree of polymerization, in fact they were discarded with the supernatant after alcoholic precipitation. The ratio soluble/insoluble fibre increased after autoclaving. This has been attributed by ANDERSON and CLYDESDALE (1980), VARO *et al.* (1984) and ARRIGONI *et al.* (1986) to a partial solubilization of pectic substances and arabinans during the hydrothermic treatment of pectins, tomato and apple pomace.

Amylolysis

In vitro α-amylolysis curves *(fig. 1)* could be divided into three parts:
- during the first 10 minutes, starch is quickly hydrolyzed by the amylase added at time 0;
- from the 10th to the 40th minute, there is a bending of the curve;
- finally, the third phase of the curve is linear, the slope being slight. This straight line can be extrapolated to calculate the "easily digestible starch".

Six percent of beet fibre in the semi-synthetic diet significantly ($p < 0.01$) decreased the initial speed of starch degradation (between times 0 and 10 min) *(fig. 2)*. However at the end of the hydrolysis, the percentage of hydrolyzed starch was not significantly higher in the fibre-free diet compared with the beet fibre diets.

This result is in agreement with that of ISAKSSON *et al.* (1982) who concluded that low-esterified pectins decrease the α-amylase activity of human pancreatic juice *in vitro*. On the contrary, DUNAIF and SCHNEEMAN (1981) observed a positive effect by pure highly methylated pectin on pancreatic human α-amylase *in vitro*. However the same authors noted that the cellulosic and hemicellulosic parts of the fibre decreased the α-amylase activity. Beet fibre is composed of pectins but also of cellulose and hemicelluloses (MICHEL *et al.*, 1988) which could affect the activity of the α-amylase *in vitro*, explaining the decrease in the initial speed of α-amylosis.

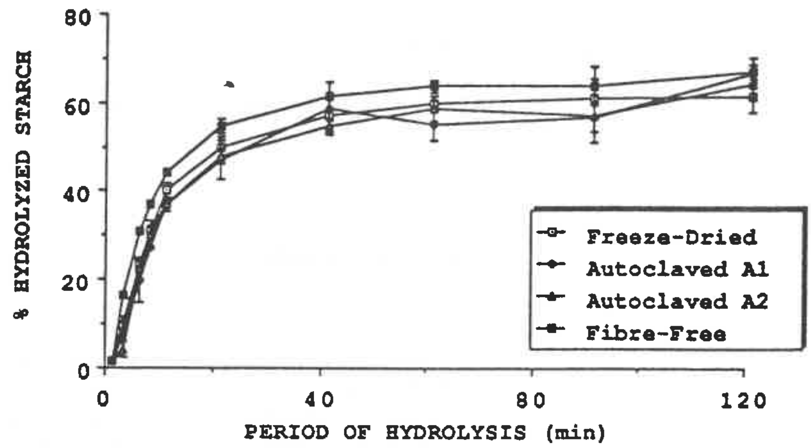

Figure 1
In vitro *amylolysis of the starch of a complex diet containing or not 6% of freeze-dried and autoclaved beet fibre, with a porcine pancreatic amylase, during 120 min*

Although the autoclaving of the beet pulp increased the soluble fibre content of the diet, the *in vitro* α-amylolysis of the starch was not affected. However the soluble fibre content of the diet remained low (2.5%). Usually higher concentration of pure soluble fibre have been shown to act on glycemia (JENKINS *et al.*, 1978; SCHWARTZ *et al.*, 1988).

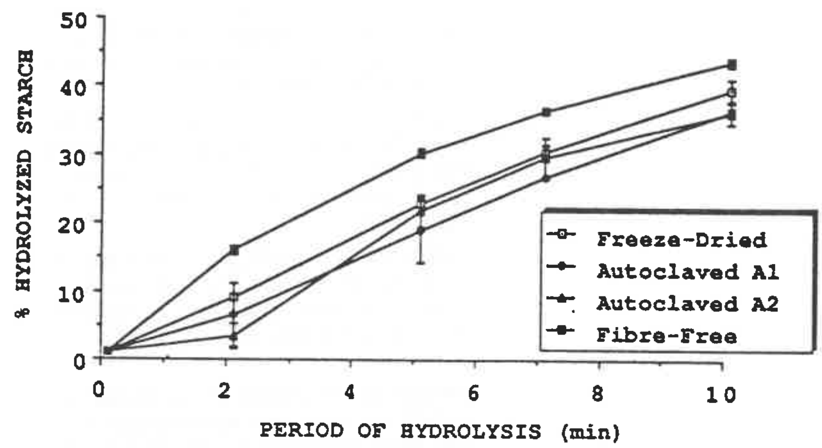

Figure 2
Initial (the first 10 min) in vitro *amylolysis of the starch of a complex diet containing or not 6% of freeze-dried and autoclaved beet fibre*

Furthermore the viscosity of these fibre has been suggested as a significant parameter for their effects. In our study, the soluble fibre of beet pulp might have been not viscous enough. Indeed, GUILLON (1989) has shown that the low molecular weight compounds formed in autoclaving of beet pulp cannot increase the viscosity of the medium.

4 - CONCLUSION

The presence of 6% of beet fibre changed the initial pattern of the *in vitro* α-amylolysis of the starch contained in a complex diet. However the increase in the soluble fibre fraction from 15% to 30% did not reinforce this effect. This may be due to the weak viscosity of beet pectins.

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