Shrivelled grain potentially worth more than chicken feed

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Abstract

Shrivelled grain was separated from plump grain for three varieties of wheat grown at the same site. Each grain size, plus a composite sample taken before separation, were analysed for rapidly- and slowly-digestible starch. There were varietal differences in the proportion of total digestible starch present as the rapidly-digestible fraction. While there were no significant differences between the plump grain and the composite sample in terms of starch composition, shrivelled grain contained significantly less ($P<0.001$) rapidly-digestible starch than the plump grain and composite samples, while maintaining a similar level of slowly-digestible starch. In shrivelled grain, 3.2?% of the total digestible starch was rapidly-digestible, compared with 10.8?% and 8.8?% in the plump grain and the composite samples respectively.

The lower proportion of rapidly-digestible starch in shrivelled grain provides evidence that this by-product of wheat production may be usefully targeted for the manufacture of low glycaemic index foods.

Media summary

Shrivelled grain, traditionally used as chicken feed, shows potential for production of low glycaemic index foods.

Key words

GI, glycaemic index, wheat grain screenings.

Introduction

The composition of starch in food is partly responsible for the glycaemic index (GI), which has become an important measure of the ability of a food to cause a spike in blood glucose and, in sufferers of diabetes, the dangerous post-consumption glucose low. Rapidly-digestible starch has been positively correlated with GI, whereas slowly-digestible starch is negatively correlated (Englyst *et al.*, 1999; Araya *et al.*, 2002; Englyst *et al.*, 2003). Therefore, agricultural commodities (especially grains) with a higher proportion of starch present as the slowly-digestible fraction are preferable for the production of low GI foods. While many comparisons have been made between different foods in terms of GI (Foster-Powell *et al.*, 2002) and studies have indicated how environmental conditions can affect total starch content in wheat (Jenner *et al.*, 1991), there is no information available on how environmental conditions may alter the proportions of slowly- or rapidly-digestible fractions, and hence the GI.

Jenner *et al.* (1991) reported that stressful growing conditions (e.g. drought or high temperature) caused a decrease in total starch deposition and often resulted in a greater proportion of small or shrivelled grain. The aim of this study was to determine if shrivelled grain differs in starch composition to plump grain grown under the same conditions.

Methods

Grain

Three historical wheat varieties (Baroota Wonder, Federation, and Gabo) were grown in multiplication plots at the same site near Roseworthy, SA, in 1997 under rainfed conditions, with annual rainfall of 447 mm. Grain was harvested with a small plot harvester and stored at 4^{0}C before three samples were prepared for comparison, i.e. a composite comprising plump, shrivelled and broken grain; plump grains that would not pass through a 2 mm sieve; shrivelled grain which was manually sorted from the broken grains present in the screenings. Samples were air dried for 48 hr and then ground for 10 seconds using an IKA mill.

Starch analysis

The rapidly- and slowly-digestible starch fractions were determined in duplicate based on the enzymatic method of Englyst *et al.*, (1992). Samples (approximately 1 g) plus sodium maleate buffer (pH 6.0) and alpha-amylase, invertase and amyloglucosidase, were horizontally shaken (with glass balls) at $37?^{0}$C. Sub-samples were taken at 20 min (to determine rapidly-digestible starch) and 120 min (to determine slowly-digestible starch) and mixed with ethanol. Glucose contents were determined using the Megazyme glucose assay, incubating with the reagent for 20 min at 40?C and reading absorbance at 510 nm.

Free glucose was determined based on Englyst *et al.*, (1992) by placing samples (approximately 1 g) plus sodium maleate buffer (pH 6.0) in 100?C water bath for 30 min, then shaking horizontally (with glass balls) at 37?C after the addition of invertase. A sub-sample was mixed with ethanol, and glucose content determined.

Rapidly-digestible starch (g/100 g) was calculated as the glucose determined in the 20 min sample minus free glucose, and multiplied by 0.9 to convert from free glucose to anhydroglucose as present in starch. Total digestible starch (g/100 g) was calculated similarly, but using the glucose determined in the 120 min sample instead of the 20 min sample. Slowly-digestible starch is the difference between the total digestible starch and the rapidly-digestible starch.

Data were analysed using 2-way analysis of variance (without blocking) in Genstat 6.

Results

The shrivelled grain contained significantly less rapidly-digestible starch than both the plump and the composite samples (Table 1). However, there was no significant difference between the grain sizes in terms of slowly-digestible starch. This resulted in a lower proportion of the digestible starch present as rapidly-digestible starch in the shrivelled grain. Free glucose was less than 2 % in all samples.

Table 1. Starch composition of shrivelled wheat grain, compared with plump and composite samples. Standard errors are included in the parentheses.

Grain size	Rapidly-digestible starch (g/100 g)	Slowly-digestible starch (g/100 g)	Rapidly-digestible starch (% of total digestible starch)
Plump (>2 mm)	6.4 (+/-0.7)	53.7 (+/-2.3)	10.8 (+/-1.4)
Shrivelled	1.7 (+/-0.8)	56.7 (+/-6.4)	3.2 (+/-1.5)
Composite	5.5 (+/-0.4)	57.6 (+/-3.6)	8.8 (+/-0.8)

F Probability	<0.001	0.813	0.001

There was no significant difference in rapidly-digestible or slowly-digestible starch between varieties (0.05<P<0.1), but the proportion of total digestible starch present as the rapidly-digestible fraction was significantly greater (P<0.05) in Baroota Wonder than Federation, with Gabo intermediate (Figure 1). There was no significant interaction between variety and grain size.

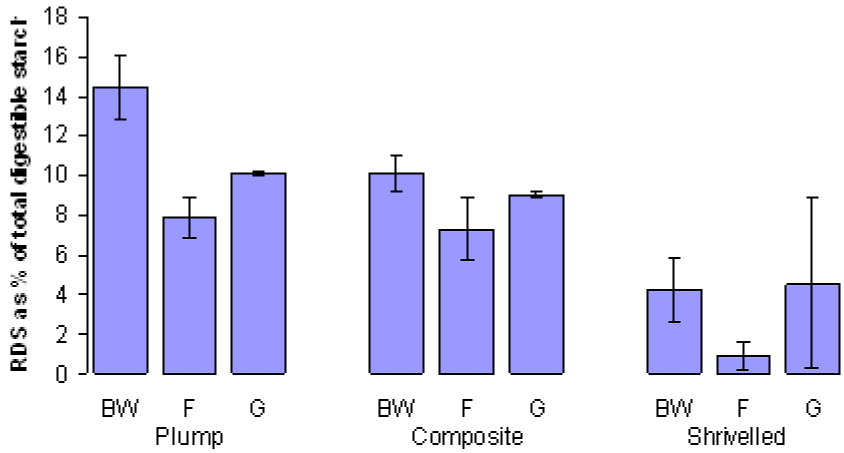

Figure 1. Rapidly-digestible starch (RDS) expressed as a percentage of the total digestible starch for plump and shrivelled wheat and a composite sample, for varieties Baroota Wonder (BW), Federation (F) and Gabo (G).

Discussion

These results indicate that shrivelled grain would have a lower GI than either plump grain or a composite sample grown under the same conditions. However, other factors than carbohydrate composition, such as rate of gastric emptying and fibre content of the meal contribute to the GI value of food (Foster-Powell *et al.*, 2002). Consequentially, the lower GI value of shrivelled grain could only be validated by *in vivo* trials. If such trials were positive, an opportunity might exist for the use of shrivelled grain in the production of low GI foods, rather than its current use as a low value product, such as chicken feed (or equivalent).

Grain affected by drought, high temperature or frost can contain a greater proportion of shrivelled grains than grain produced in more ideal conditions. It is possible that grain produced in drier climates, where protein content is increased due to a reduction in starch deposition (Jenner *et al.*, 1991), may also have a similar starch profile to shrivelled grain, but this needs to be investigated.

The varietal difference in the proportion of total digestible starch present in the rapidly-digestible fraction indicates that there is potential for identifying certain varieties of wheat with lower GI so that the best grain for low GI products could be sourced (e.g. in this study, shrivelled Federation (Figure 1)). However, to be useful this will have to be shown in varieties that are currently grown.

Conclusion

Due to the lower proportion of rapidly-digestible starch in shrivelled grain, there is potential to value-add shrivelled grain for use in the production of low GI foods.

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