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BARLEY STARCH

Abstract

Large variations in yield of dry matter and starch were found for different barley cultivars, including barleys with different amylose content. The microstructure, e. g. in granule size distributions, also differed between cultivars. In a waxy barley starch granules with a high content of amylose were found in the subaleurone layer, showing that different types of granules were found in different parts of the endosperm. The amylopectin in starch with different amylose content had similar chain length distributions and gelatinization characteristics.

Introduction

Barley is a very old cultivated crop. Today it is mainly used in animal feed and for malting in developed countries but in certain areas, like Korea and West Asia/North Africa the human consumption of this cereal is still quite high. In Western countries barley may be rediscovered as a food grain since it has many interesting nutritional properties like a high content of mixed-linked β-glucan which may reduce the serum cholesterol levels [1] and relatively resistant endosperm cell walls, which in products with intact structures may reduce the postprandial blood glucose and insulin responses after a meal [2].

Barley is extensively used in genetic studies due to its diploid and self-fertile nature, ease of hybridization and a large number of easily classified characters. The barleys cultivated today have characteristics such as winter/spring, two-rowed/six-rowed, covered/naked, high amylopectin starch (waxy)/low amylopectin starch, high mixed-linked β-glucan/low mixed-linked β-glucan and high protein or lysin. Several of the above mentioned characteristics have been combined in new barley genotypes. For example the starch content in barley varies widely and ranges from 21.2–66.6% [3-4]. This variation may depend on both growing conditions and cultivar.

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Industrial processing of starch from barley is very limited, and to our knowledge only one full scale plant in Finland is operating [5]. The combination of a relatively low starch content, a high fibre content and that barley contains viscous and gelling materials which need special process steps, including the use of added enzymes, lead to that the products must have an added value compared to starch and byproducts from the traditional plants which generally use corn, wheat or potato as raw materials.

Barley starch with low (0–14%), normal (19–30%) and high (35–45%) amylose content are available today [6-8]. Especially the low amylose starch has rendered great interest during recent time due to its excellent freeze/thaw stability. The high amylose types could be of nutritional interest in products for control of blood glucose and insulin levels due to a significant formation of resistant starch in many processed foods.

In this proceeding we will report some results from our work on new barley types with low, normal or high amylose content. Results from both Swedish field experiments and chemical and physical studies will be presented.

Results and discussion

Effect of cultivar and environment on yield and grain quality

Ten barley cultivars including covered and naked types varying in their content of total starch, amylose, protein and β-glucan, were grown in different years, at various locations and nitrogen fertilization rates [9]. The barleys showed large variations in yield (3250–6690 kg/ha), starch content (51–67 % of DM), starch yield (1870–3840 kg/ha), protein content (8–15% of DM) and β-glucan content (3.5–5.9%). The naked and high amylose barley Hashonucier had the lowest yield and starch yield while the covered feed barley Lina had the highest. As the effect of year and location was generally less pronounced than the effect of N-rate, the yield and analysed variables were calculated as average values for the ten cultivars at the different N-rates. For all barleys the yield and protein content increased with higher nitrogen fertilization rates while the starch content decreased. Most of the barleys also showed higher β-glucan contents.

Composition and microstructure of barley samples

Barley samples with a low (about 8%, waxy, SW 7142-92), normal (about 25%, Golf) and high (about 40%, naked Hashonucier and covered high amylose Glacier) amylose content were used in this investigation on the composition and microstructure (10). Growing location or nitrogen fertilization did not notably influence endosperm thickness or cell size in the different barleys in this limited study. Golf had overall thinner starchy endosperm cell walls and the chemical composition also showed that it contained less β-glucan than the waxy and high amylose samples. In Hashonucier and high amylose Glacier the starch granules were more even in size compared with Golf, which showed a typical bimodal distribution.In the waxy sample it was shown that medium sized granules which stained black with iodine, indicating a high amylose content, were located in the subaleurone layer while the rest of the granules stained more brownish. Consequently different types of starch granules were present in different parts of the endosperm.

In order to confirm the high amylose content in granules in the subaleurone layer, inner and peripheral parts of the kernels were isolated by pearling [11]. Chemical analyses of amylose content in isolated starch indeed showed that there was a higher concentration of amylose in the outer parts of the starchy endosperm.

Characterization of starch isolated from different types of barley

Starch was isolated from pearled waxy (line 906129) normal (Golf), and high amylose (high amylose Glacier) barleys [12]. Small starch granules tended to associate to the protein fraction and may partly have been lost during the isolation procedure. The starch granules of the barleys with normal and low amylose content had similar size distribution profiles as measured by Coulter Counter and as revealed by scanning electron microscopy. The high amylose barley had smaller A-granules. The content of total amylose, as determined by iodine staining, was 5.6% in the waxy starch, 27% in the normal starch and 37% in the high amylose starch and the content of lipid complexed amylose (LAM) 2.4, 5.5 and 7.5%, respectively. Total amylose content as determined by gel permeation chromatography after debranching was generally 2%-units higher as compared to the results obtained by iodine staining.

The amylopectin unit chain length distribution of the three barleys were examined by high performance size exclusion chromatography, after debranching with isoamylase [12]. All three amylopectins showed a polymodal unit chain length distribution, with local peak maxima or shoulders at DP 12, 18–19 and 46–47. The weight average chain lengths were for the waxy starch 26.7, the normal amylose starch 25.8 and the high amylose starch 24.0. Consequently the high amylose barley seems to have amylopectin with somewhat shorter unit chains than the other two barleys. DSC gelatinization endotherms of the three starches were studied at a starch:water ratio of approximately 1:1. The enthalpy of gelation of the amylopectin were similar in the three samples (range 15.6–16.1 J/g amylopectin). As a general conclusion all three amylopectins had similar structural and gelatinization characteristics.

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Streszczenie

Dla różnych odmian jęczmienia, włącznie z odmianami o różnych zawartościach amylozy stwierdzono duże zmiany w zawartości suchej masy oraz skrobi. Mikrostruktura tzn. skład ziarnistości dla różnych odmian również był zróżnicowany. W skrobi jęczmiennej woskowej w warstwie podaleuronowej znaleziono gałeczki o wysokiej zawartości amylozy pokazując, że w różnych częściach endospermy znajdują się różne rodzaje gałęczek. Amylopektyna w skrobi o różnej zawartości amylozy miała podobną długość łańcucha i podobną charakterystykę kleikowania.