Appendix 1

APPENDIX 1

Barley Processing and Definitions

BARLEY PROCESSING

Food Barley

Two types of barley are grown for the food industry. The predominate barley type by far is the covered or (hulled) form, which has a tough fibrous outer coat that strongly adheres to the barley kernel. Anatomically these outer structures are referred to as the lemma and palea, however the common term used to describe the outer covering is "hull". The second form of commercial food barley is the hulless or "naked" barley. Hulless barley is currently only used for specialty products but offers a great deal of promise as an ingredient in a broad range of food products. The two barley types are very similar on a structural basis except for the hull. In the case of the hulless type, the hull is lost during harvest (similar to wheat) and the resulting kernel or berry can be processed directly into food products. In the case of traditional barley, the tough fibrous hull is literally cemented to the kernel and must be removed using a milling process commonly referred to as pearling. Figure A.1.1 illustrates a typical barley pearling process (using decorticators) and identifies several barley product categories. Pearling is an abrasive scouring process that gradually removes the outer cell layers and is commonly done in three stages. The degree of pearling (typically stated in %) refers to the amount of kernel removed during processing. For reference purposes, Figure A.1.2 illustrates the structure of a barley kernel and shows the specific location of each tissue layer. The first stage or mildest form is termed "blocking" which only removes the hull and a small amount of the outer bran layer. This "dehulling" step typically removes 15-25% of the kernel and the end product is referred to as "dehulled barley". The second pearling stage removes an additional 10 % of the kernel, mostly pericarp and the germ fraction, and the resulting product is referred to as "pot barley".

Figure A.1.1. Traditional Barley Processing[a]

Whole Grain Barley (hulled)

⇩

Carter Disk Separators – size barley (separate non –barley contaminates)

⇩

Aspirate (remove fine particles and dust)

⇩

Flat Stone Mill – (Remove hull tips ~ 5% by weight)

⇩

Decorticator 1 (pearling machine) –

⇩ Remove hulls and bran ~ 25% by weight. Produces **dehulled barley.**

Hammer mill or Steam-flaking mill – **whole grain grits, meal or flakes.**
Roller mill – **flour/flour fractions and bran.**

Decorticator 2

⇩ Remove bran and germ ~ 10% by weight. Produces **pot barley.**

Hammer mill or Steam-flaking mill – **pearled grits, meal, white flakes** for breakfast cereal and seibaku.
Roller Mill - **flour/flour fractions** for bread bakery blends and baby foods.

Aspirate (removes fines)

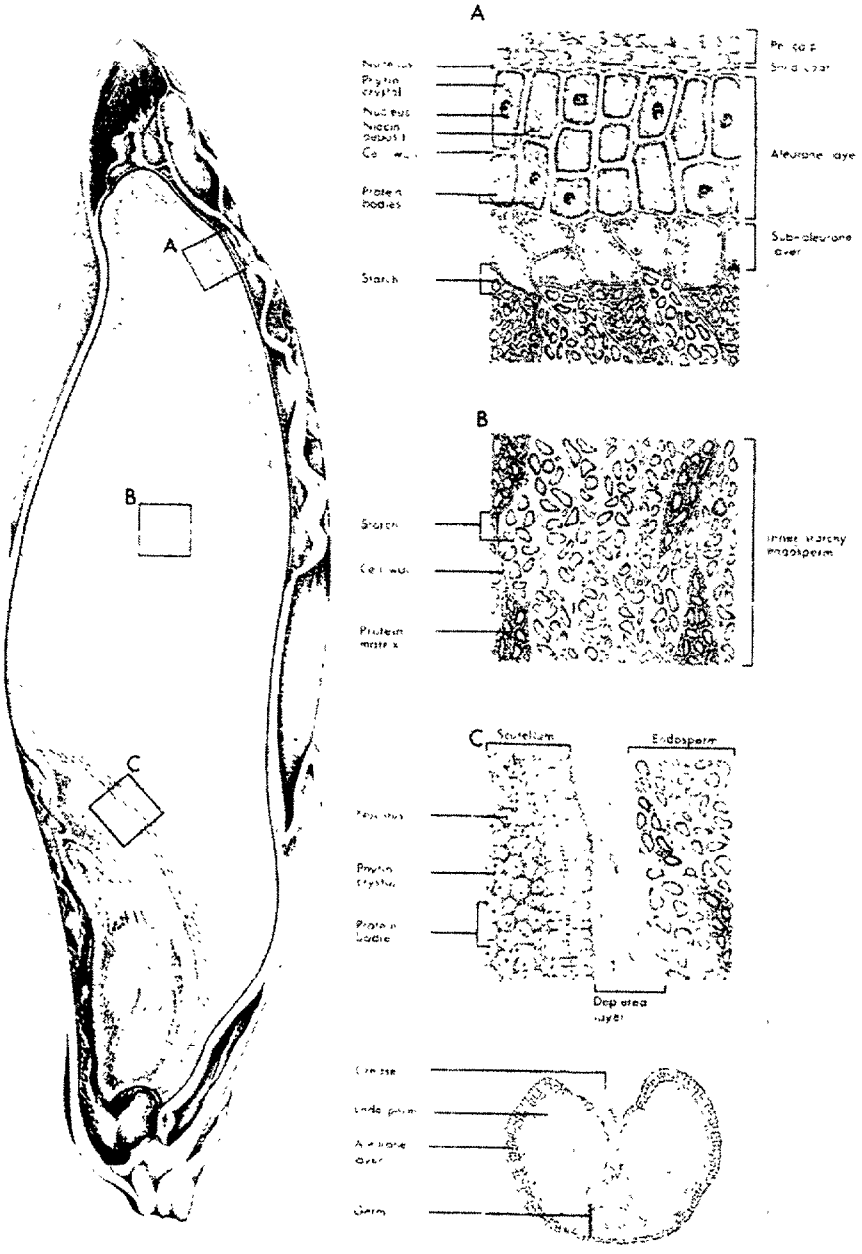
⇩

Decorticator 3

Removes crease bran, aleurone and outer endosperm ~10% by weight. Produces **pearled barley** for use in soups, pilafs and as an ingredient in various foods.

[a]Adapted from Bhatty 1993b.

Figure A.1.2. Structure of the barley kernel sectioned longitudinally and transversely with detailed insets of the bran layer (A), starchy endosperm (B), and embryo endosperm interface (C). Taken from, Izydorczyk et al 2002.



The third and final stage removes another 10% of the kernel and produces "pearled barley". The remainder of the seed coat, aleurone and a portion of the subaleurone layers are removed in this final stage. Pearled barley typically represents 60-70% of the original barley kernel. Note pearled barley, from any one of the three pearling stages, can be used as the starting material to produce barley grits, meal, flakes, flour, or β-glucan enriched flour fractions.

Pearling of covered barley has a similar function to impact dehulling of standard oats, i.e. hull removal. However, in the case of barley additional tissue layers are removed especially during the second and third pearling stages. A key question then is, " what impact does this have on β-glucan content. Figure A.1.3 shows that the β-glucan content of the pearled product actually increases in each pearling stage. Conversely, insoluble dietary fiber decreases during this process. These findings highlight the subtle difference between barley and oats with respect to anatomical distribution of β-glucan.

Other milling techniques, such as roller milling commonly used on other cereal grains can be applied to both dehulled and hulless barley. Although the use of alternative milling procedures is not currently a common practice in the barley industry, these techniques could be used to produce a wide variety of specialty barley products highly enriched in β-glucan (Lee et al, 1997; Knuckles and Chiu, 1995; Vasanthan and Bhatty, 1995; Andersson et al, 2000). While not a typical barley product, bran is produced in both pearling and roller milling. Bhatty (1997) reported that 30% pearling removed all of the pericarp, testa, aleurone and subaleurone in hulless barley. These outer coverings in this 30% fraction constitute a "true bran" according to the

definition in the AACC barley glossary (Table A.1.1). Bran has been reported to contain from 50% less to 50% more β-glucan soluble fiber content than its source barley grain (Fastnaught 2001) depending on the processing method and actual yield. Because barley, unlike oats, has a uniform distribution of β-glucan throughout the kernel, removal of the outer layers (bran in the case of oats) does not reduce the β-glucan content of barley but rather increases the β-glucan content of all traditional barley products. This provides the opportunity to develop and utilize a wide range of unique barley ingredients for heart health oriented products that deliver the target barley β-glucan soluble fiber.

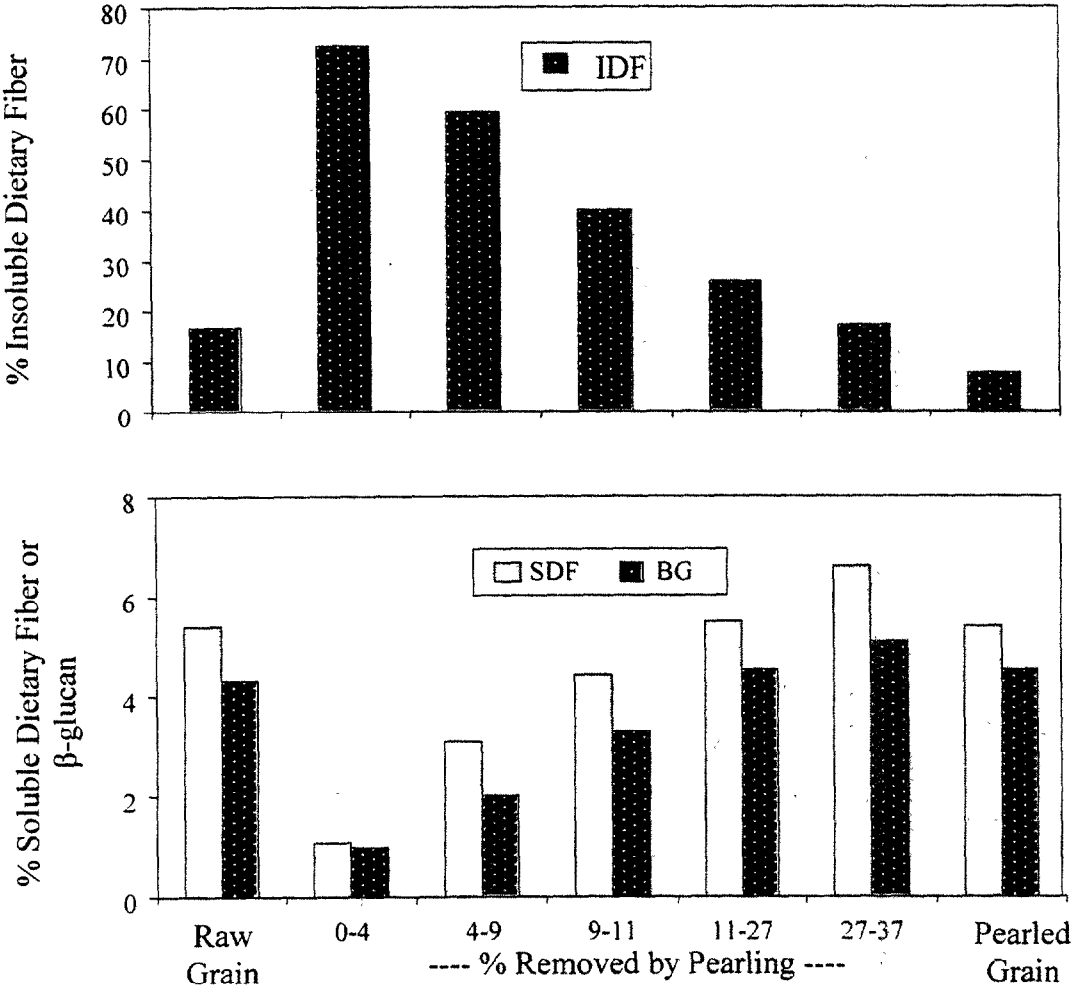


Figure A.1.3. Levels of insoluble and soluble dietary fiber and β-glucan in raw and pearled grain and fractions removed from barley by pearling an English (covered, normal starch) variety. Data taken from Marconi et al. 2000.

Table A.1.1. BARLEY GLOSSARY[a,b]

Barley. The fourth major world cereal belonging to the family *Poacea*, the tribe*Triticeae* and the genus *Hordeum*. All cultivated barley belongs to *Hordeum vulgare*. Cultivated barley can have either the 2-row or 6-row head type upon which either hulled or hulless seed develop.

Barley Bran. A product of roller or separation milling of *dehulled* or *hulless barley*, which includes the outer covering such as pericarp (nucellar epidermis), testa (seed coat), aleurone and subaleurone layers. Should be free of hulls. May also be a combination of milled bran and shorts fractions.

Barley Brewers Grain. A by-product from the malting and brewing processes, consisting principally of the hull, germ, oil, protein and unfermentable fiber. Also known as brewers spent grain.

Barley Flakes. *Dehulled, pearl* or *hulless barley* that may be enzyme deactivated and/or tempered followed by the process of being rolled, dried and cooled. Flake thickness can be varied depending upon original grain form and degree of rolling pressure.

Barley Flour. Produced by dry milling of barley, consisting principally of endosperm tissue. Extraction rate may vary in flour produced from roller/separation milling.

Barley Germ. The germ consists of the embryonic axis and the scutellum, usually obtained by separation from *barley bran* or *barley pearlings*.

Barley Grits. *Dehulled, pearl* or *hulless barley* that has been cut into small pieces. Also known as barley bits.

Barley Hulls. Outer coverings of the barley kernel, consisting of the two flowering glumes, lemma and palea, which may or may not adhere to the pericarp. Also known as husks.

Barley Malt. Product from soaking or steeping the whole barley kernel followed by germination and drying (kilning) in a controlled environment.

Barley Pearlings. The residue from the pearling process consisting of hulls, pericarp, testa, aleurone, subaleurone, germ and various percentages of the endosperm depending upon the degree of pearling. The hulls are not part of the pearlings when *dehulled* or *hulless barley* is pearled.

Barley Shorts. A fraction of the barley milling process, separate from bran and flour.

Dehulled Barley. *Hulled barley* from which the hulls have been removed by a physical process.

High Amylose Barley. Barley having the homozygous recessive gene *amo* 1 which increases the percentage of amylose in the starch up to 40-45% compared to the normal 25-30% amylose.

Hulled Barley. Barley in which the two flowering glumes, lemma and palea, adhere to the seed. Also known as covered barley.

Hulless Barley. Barley having the homozygous recessive gene *nud*, which prevents the hulls (flowering glumes) from adhering to the seed. Also known as naked barley.

Pearl Barley. A barley product in which the hulls, pericarp, testa, germ and part of the outer endosperm are removed by an abrasive scouring process. Coarse, medium or fine pearl can be produced by increasing the amount of abrasion. Other terminology of pearl barley may include blocked, pot or scotch barley.

Waxy Barley. Barley having the homozygous recessive gene *wax* which produces starch that is principally or completely amylopectin.

Whole Grain Barley Products. Flour, grits, flakes or other products made from barley that include the bran, germ and endosperm. Whole grain barley flour may also be known as whole barley meal.

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[a]Taken from, AACC Method 55-99 (2000).
[b]These terms have been defined specifically for barley and may have different definitions when used in other contexts.

Appendix 1 – References

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