CLASSIFYING MALT BY SIEVING AND AIR CENTRIFUGING-ELUTRIATING TECHNIQUES

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ABSTRACT

Commercial barley malt flour was separated by conventional sieving and by air centrifugation-elutriation on a laboratory microclassifier according to particle size into fractions of various compositions. Scanning electron micrographs were used to determine particle size of, and to characterize particles in, separated fractions. The fractions varied in protein and mineral contents (total ash, K, P, Mg, Ca, Mn, and Zn) and in amylolytic activity (α-amylase and diastatic power). The original malt and each of the nine fractions were added at four α-amylase levels to a no-sugar dough to provide the source of fermentable sugars in breadmaking. Adding malt decreased water absorption (up to 1.6%) and mixing time (up to 3/8 min). Added on an equivalent α-amylase basis, the original malt and all malt fractions increased loaf volume equally. Loaf volume of bread (100 g - flour) baked without added sugar or malt was 408 cc; adding 27, 54, 81, or 108 D.U. (dextrinizing units, 20°C), respectively, increased average loaf volume to 881, 928, 933, and 935 cc; 54 D.U. was optimum. Contribution of malt to bread quality was unaffected by particle size or composition of the malt, provided equivalent α-amylase was added. Increasing α-amylase to twice the optimum had no adverse effects on dough-handling properties, but produced bread with slightly open crumb grain.

Air classification of wheat flour is a relatively inexpensive way to manufacture uniform flours from various wheats, to control particle size and composition, and to produce special flours. We know of no published report on use of air classification to fractionate malt flour. This study was undertaken to determine the feasibility of using such fractionation to obtain malt flours of various compositions and enzymatic activities and to determine the effects of variations in malt composition in production of bread baked using a no-sugar formula (1–3). Malt flour was fractionated by sieving and by air centrifugation-elutriation on a laboratory microclassifier.

MATERIALS AND METHODS

Malt Flour

The barley malt flour was a commercial product (Amylomalt) manufactured as a diastatic supplement for breadmaking.

Malt Flour Fractions

The barley malt flour was separated into two main fractions by sieving 20-g samples for 10 min on an 8-in. diameter Ro-Tap Testing Sieve Shaker, U.S. Tyler Co. Two Carmichael cleaners with nylon brushes were placed on each sieve to assist in separation. The two main fractions were overs (O) and throughs (T) of a

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Tyler sieve 250 with 63-μm sieve openings.

The overs were then separated into four fractions by sieving through standard Tyler sieves 115, 150, 170, and 200.

The throughs of the Tyler sieve 250 were separated into three fractions on a Bahco Microparticle Classifier, according to the manufacturer's instructions. The use of the classifier in standard tests for determining properties of fine particulate matter was described in the Power Test Committee 28 (4) and in Publication 64-WA/PTC-3 of the American Society of Mechanical Engineers (5). The classifier is a combination air-centrifuge-elutriator. It separates a dry powder according to terminal settling velocity. The particles in the powder are subjected to a centrifugal force opposed by a current of air. By varying the air current, by means of a throttle, it is possible to change the particle-size limit of separation, and by using one or more of eight available throttles (or air-orifice settings), the material can be divided into nine fractions.

The throughs of the Tyler Sieve No. 250 were first separated on the classifier with the throttle setting of 14. That yielded a fine fraction B-3 and a residue. The residue was then separated with the throttle setting of 8, which yielded the medium fraction B-2 and a coarse fraction B-1.

Some physical and chemical characteristics of the original barley malt and of the fractions separated by sieving and air centrifugation-elutriation are described in Table I. The SEM micrographs showed the following average particle sizes and shapes for the Tyler sieve (O = overs, T = throughs) and Bahco (B) fractions:

Fraction	*Average particle size* (μm)	*Description*
Over 250		
O-150, T-115	230 × 100	Mixture of flat-long, round, or square chunks
O-170, T-150	160 × 100	Relatively uniform in size, variable in shape (flat, sphere, chunk)
O-200, T-170	140 × 90	Relatively uniform in size, mostly square
O-250, T-200	120 × 80	Widely varying in size and shape
Through 250		
B-1	80 × 50	Relatively uniform in size, varying shape
B-2	20 × 20	Most round, a few chunks
B-3	15 × 15	Squares and spheres, very few chunks

Particle size expected from openings of Tyler sieves or Bahco separation agreed well with results of measuring size of particles in SEM micrographs (averages of 25 measurements).

Analytical Procedures

Moisture, protein, and ash were determined as described in AACC Approved Methods 44-15A, 46-11, and 08-01, respectively (6). Protein is expressed as Kjeldahl N × 5.7% on a 14% mb.

Diastatic power and α-amylase were determined according to the American Society of Brewing Chemists Methods of Analysis (7); phosphorus by a colorimetric (Mo)-blue method (8); and mineral analyses by atomic absorption spectroscopy according to the procedure described by Liu *et al.* (9), except that the measurements were made on a Perkin-Elmer Model 306 atomic absorption spectrophotometer.

The baking procedure of Finney and Barmore (10–12) and Finney (13), for 100 g flour (14% mb) was used in a sugar-free formula, except that 10 ppm potassium bromate and 100 ppm ascorbic acid were used as oxidizing agents (14). Standard deviation for the average of duplicate loaf volumes was 20 cc.

Microscopic Examinations

For examination by scanning electron microscopy (SEM), the malt samples were placed on double-stick Scotch tape mounted on 9-mm diameter aluminum specimen holders. The samples were coated with a 10-nm layer of graphite and a 15-nm layer of gold, and viewed and photographed in an ETEC Autoscan electron microscope at an accelerating voltage of 5 kV.

RESULTS AND DISCUSSION

The two main fractions (overs and throughs of Tyler sieve 250) varied widely in

TABLE I
Some Physical and Chemical Characteristics of Barley Malt and its Fractions

Amylomalt and Fractions	Part of Total %	Particle-Size Range μm	Protein[a] %	Diastatic Power[b]	α-Amylase D.U. units/g
Amylomalt	100.0	< 13–125	10.6	194	54.1
Over 250[c]	46.0	≥61	12.5	235	71.1
O-150, T-115	4.7	≥105–125	14.2	221	67.4
O-170, T-150	9.0	≥ 88, <105	13.5	198	69.8
O-200, T-170	14.9	≥ 74, < 88	12.4	242	73.8
O-250, T-200	17.4	≥61, < 74	11.5	224	63.0
Thru 250[d]	54.0	≤61	9.1	158	43.6
B-1[c]	12.3	34–61	10.5	235	67.4
B-2	29.1	13–34	7.6	123	36.2
B-3	12.6	≤13	10.8	147	41.7

[a]14% moisture basis.
[b]Arbitrary units.
[c]Numbers following Over (O) and Thru (T) refer to Tyler sieve meshes/in.
[d]B-1, B-2, and B-3 are abbreviations for the coarse, medium, and fine Bahco fractions of the 250 thrus. B-3 is the effluent fraction from the first throttle setting of 14, which yields a residue of B-2 plus B-1. B-2 is the effluent fraction from the second throttle setting of 8, which yields the residue B-1.

protein content, diastatic power, and α-amylase activity (Table I). The coarser, protein-rich fraction (over 250) was substantially higher in diastatic power and α-amylase than the finer protein-low fraction (through 250). One of the coarse fractions contained 73.8 D.U.[2]/g (compared with 54.1 D.U. in the original malt flour). Subfractionation either by sieving or by centrifugation-elutriation did not yield subfractions consistently high in both protein content and enzymatic activity. None of the sieved subfractions was considerably higher in diastatic power or α-amylase than the parent fraction (over 250). The Bahco microparticle classifier separated the small particle-size cut into fractions of various protein contents (7.6–10.8%), α-amylase (36.2–67.4 D.U./g), and diastatic power (125–235 units/g). Among the Bahco-separated fractions, the residue from two separations with the highest particle size (B-1) was considerably higher in both diastatic power and α-amylase than the parent (through 250) fraction. Fractions B-2 and B-3 were materially lower in diastatic activity and α-amylase than B-1 or the original malt.

[2]Dextrinizing units, 20°C.

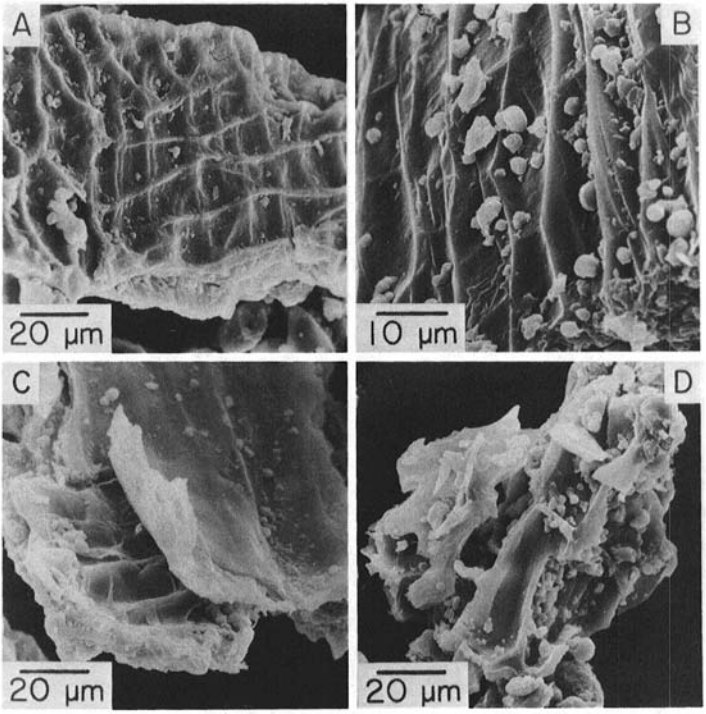

Fig. 1. Scanning electron micrographs of bran and aleurone layer particles in malt: A = bran particle in unfractionated malt, B = bran particle in the Tyler sieved fraction of overs 150 mesh/inch ($\geq$ 105 μm, < 125 μm), C = bran particle in the Tyler sieved fraction of overs 150 mesh/inch ($\geq$ 105 μm, < 125 μm), and D = aleurone layer particle in unfractionated malt.

Examination of the malt fractions by SEM revealed that the overs of the 150-mesh sieve contained primarily bran particles (Fig. 1, B and C). A bran particle and an aleurone layer particle in unfractionated malt are shown in Fig. 1, A and D, respectively. The Bahco-separated fine fraction (Fig. 2, C) contained mainly pitted starch granules. The layer-like structure of the corroded starch granules is shown at low magnification in Fig. 2, B, and at higher magnification in Fig. 2, D.

The shifts in protein contents and enzymatic activities during fractionation of the malt were accompanied by significant shifts in total ash and mineral components (Figs. 3 and 4). The over 250 and especially the two high-protein coarse fractions from sieving (O-150, T-115 and O-170, T-150) contained more total ash, K, P, Mg, Ca, Mn, and Zn than the original malt and nearly all other malt fractions. The lowest protein Bahco fraction (B-2) was also lowest in total ash and in all mineral components; the other two Bahco fractions (B-1 and B-3) had comparable protein contents, but differed in ash. In addition to the above mineral elements, Fe and Cu were also determined. The results are not reported,

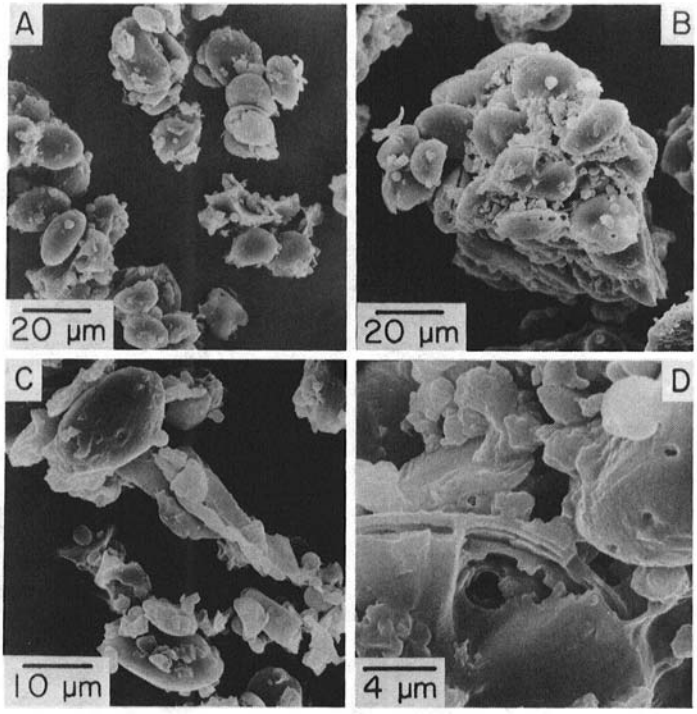

Fig. 2. Scanning electron micrographs of starchy endosperm particles in malt: A = starch granules and adhering protein particles in original malt, B = a large particle comprising starch granules in a protein matrix in a malt fraction (overs of 250 mesh/inch sieve, $\geq$ 61 μm)—note the highly pitted-corroded starch granules, C = starch granules in Bahco-separated fine fraction (B-3, $\leq$ 13 μm), and D = high magnification of some highly pitted-corroded starch granules in Fig. 2,B.

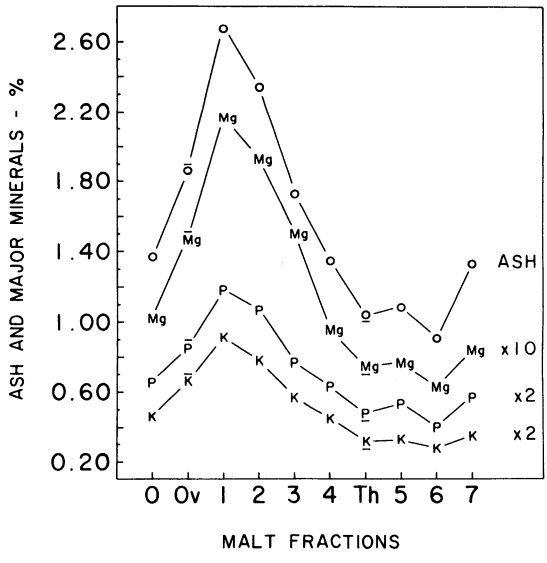

Fig. 3. Ash, K, P, and Mg contents of barley Amylomalt and its fractions: O = original malt flour; OV, 1, 2, 3, and 4 = over 250, over 150-through 115, over 170-through 150, over 200-through 170, and over 250 and through 200 Tyler sieve mesh/inch, respectively; Th = through 250 Tyler sieve mesh/inch; and 5, 6, and 7 = Bahco Microparticle Classifier separated coarse, medium, and fine fractions, respectively.

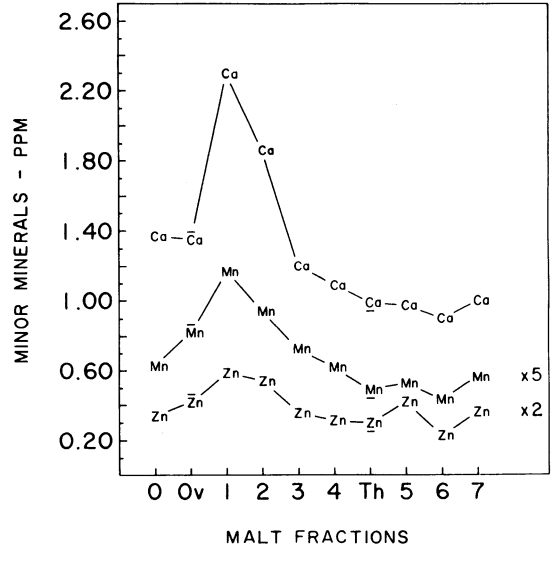

Fig. 4. Ca, Mn, and Zn contents of barley Amylomalt and its fractions. Legend as in Fig. 3.

as it was impossible to eliminate the increase in those elements from the sieves and the Bahco classifier.

Bread was baked with four α-amylase levels (27, 54, 81, and 108 D.U./100 g flour) each of the original malt, two main fractions, and seven subfractions. On the average, increasing malt had no consistent or significant effect on water absorption; however, water absorption of all malt-supplemented doughs was 0.5–1.6% below that of the control dough (water absorption of 68.6%). On the average, increasing malt decreased mixing time from 4 min (in the control) to 3-7/8 min in the doughs with 54 or 81 D.U. and to 3-5/8 min in the doughs with 108 D.U.

Added on an equivalent α-amylase basis, all malt and malt fractions increased loaf volume equally (Fig. 5). The volume of the loaf baked without added sugar or malt was 408 cc. Adding 27, 54, 81, and 108 D.U./100 g, respectively, increased loaf volume on the average to 881, 928, 933, and 935 cc. The 54 D.U.

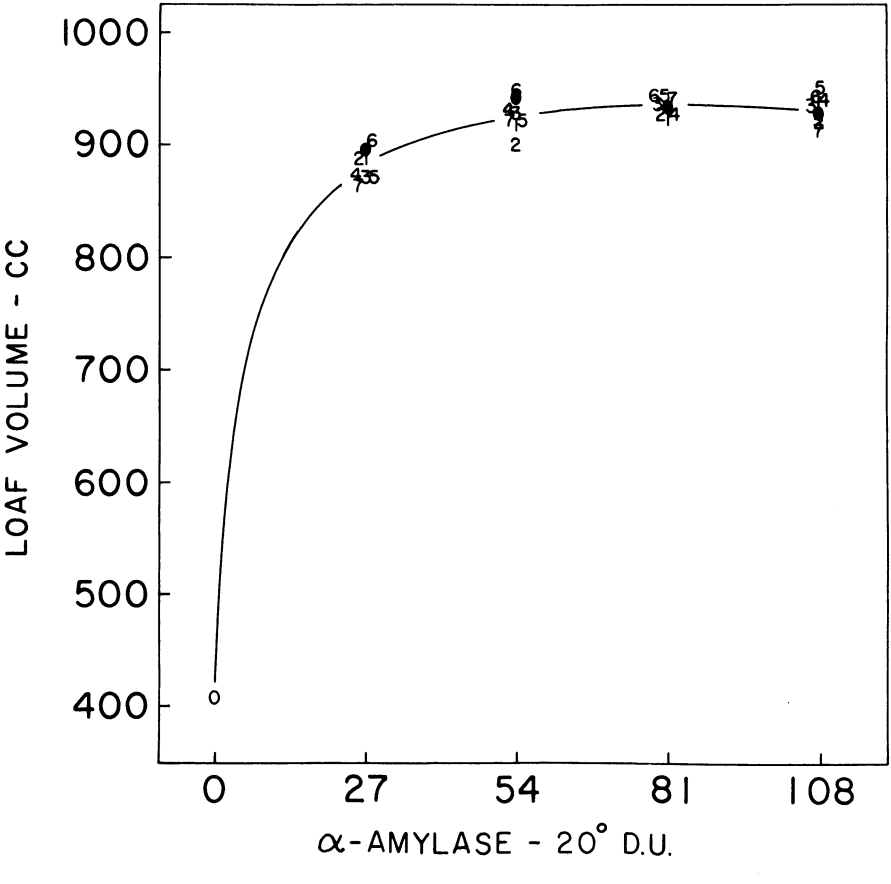

Fig. 5. Loaf volumes (cc) of bread baked from 100 g flour in a sugar-free formula containing the indicated levels of barley Amylomalt (●) and its fractions (1–4, separated by sieving; 5–7, separated by centrifugation-elutriation).

level was therefore considered optimum, as more resulted in no significant additional loaf volume increase. The contribution of the malt to bread quality was unaffected by particle size and composition of the malt, provided equivalent levels of α-amylase were added. Dough-handling properties and crumb and crust color were satisfactory at all levels of malt supplementation. At the 108 D.U. level, however, crumb grain was slightly open.

Acknowledgments

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