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Determining the distribution of ash in wheat using debranning and conductivity

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Two bread cultivars and one durum Indian wheat cultivar were evaluated for ash distribution pattern using a McGill No. 2 rice polisher. Grains of all the wheat cultivars were debranned for 30, 60, 90 and 120 s and determined for ash content. Ash content progressively decreased with the increase in debranning time. Statistical analysis showed significant differences among cultivars for ash content and weight of grain removed by debranning. Ash determined by a standard method showed a linear relationship with conductivity (R^2 value in the range of 0.93–0.99) among the cultivars. The conductivity of extract from whole and debranned grains was found to be highly influenced by extraction time as well as temperature. © 1998 Elsevier Science Ltd. All rights reserved

INTRODUCTION

Ash is an important chemical constituent for flour quality and is an indicator of flour purity. The ash in wheat is not evenly distributed throughout the kernel, being more concentrated in the bran (6%) than in the endosperm portion (0.4%) of the grain (Pomeranz, 1988). The ash content of wheat grain has been reported to vary with variety, hardness and environment (Peterson *et al.*, 1986). Singh *et al.* (1990) and Sekhon *et al.* (1992*a*) have shown unfavourable effects of hailstorms and bunt infection on both yield and ash content of flour. The milling industry throughout the world considers ash content to be an important flour quality attribute (Pomeranz, 1988). Ash content indicates how completely and efficiently the endosperm has been separated from the bran. This measurement is critical to the flour milling industry and is used to monitor the proper functioning of various milling steps. The determination of ash content, measured as oxidized residue remaining after incineration at high temperature (600°C) using standard methods, require time (5–6 h) and expensive equipment. A quick test for ash determination has always been required by the milling industry. The determination of ash by conductivity has been reported to be an alternative method to the standard ash method (Clements, 1977; Fjell *et al.*, 1996).

A number of techniques have been used to evaluate ash distribution in wheat grain. Morris *et al.* (1945) and Hinton (1959) used dissection techniques and Fares *et al.* (1996) reported the use of a frictional debranning machine as an effective and easy method to study ash distribution in wheat grain.

The present investigation was undertaken (1) to evaluate distribution of ash content in wheat by a debranning technique using a McGill No. 2 rice polisher, (2) to relate ash content to conductivity of solubles extracted from wheat and (3) to study the effect of extraction temperature and period on the conductivity of wheat grain solubles.

MATERIALS AND METHODS

Samples of bread wheat (*Triticum aestivum*) cultivars HD-2329, PBW-343 and the durum wheat (*Triticum durum*) PDW-215 were collected from the 1996–1997 crop season in Punjab, India. Samples were conditioned to 14% moisture level in triplicate for 10 min after addition of the calculated amount of water and debranned (pearled) in a McGill Miller No. 2 (Rapsco, Brookshire, TX, USA) for 30, 60, 90 and 120 s. The conditioning was necessary because of the greater slipperiness of wheat grains as compared to rice. The samples were ground to pass through a 75 μ mesh sieve in a laboratory grinder. Flour (1 g, 14% mb) was dispersed with 25 ml of deionized water for 1 h and 2 h at 30°C and 50°C with stirring at 15 min intervals. The material was then centrifuged at 4000 g for 5 min and the supernatant collected and analysed for conductivity. The

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conductivity was measured by using a digital conductivity meter, model NDC-732 (Naina Electronics, Chandigarh, India) at a fixed frequency of 1000 Hz. A dip type conductivity cell with cell constant 1.12 was used in all measurements. The accuracy of the conductance measurements was ±0.5%. Ash content of all the samples was determined using the AACC (1990) method and expressed on a 14% moisture basis. The conductivity measurements were carried out at 20°C. The data reported are averages of three replications. Data in Table 1 were subjected to analysis of variance (Steel and Torrie, 1960).

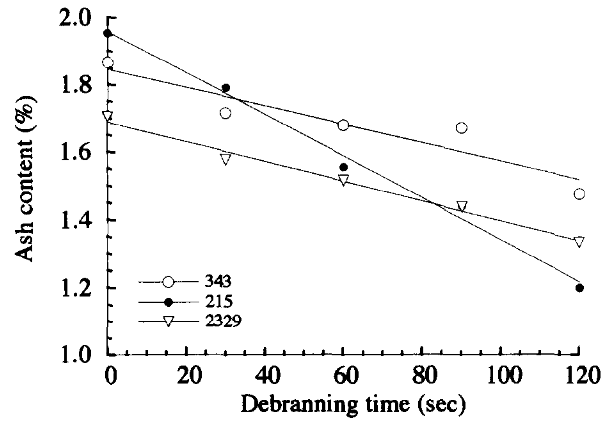

Fig. 1. Relationship between ash content and debranning for different cultivars.

RESULTS AND DISSCUSSION

Significant differences in ash contents were found among the cultivars. PDW-215 whole grain showed the highest ash content, i.e. 1.95% against a lowest value of 1.70% for HD-2329 whole grain (Table 1). The debranning showed a highly significant effect on the ash content of whole kernel. The ash content of wheat grain progressively decreased as the debranning time increased in all the cultivars (Fig. 1). Linear regression models for the relationship between ash content and debranning time for different cultivars are shown in Table 2. The relative rates of reduction in ash content among different cultivars were calculated assuming the rate constant for HD-2329 to be 1 over a debranning period of 120 s. The rates of reduction in ash content for PBW-343 and PDW-215 were 1.5 and 3.0 times faster, respectively, than HD-2329. Debranning for 30, 60, 90 and 120 s, respectively, resulted in loss of ash content of 8.03, 9.96, 10.45 and 20.90% in PBW-343 and 7.45, 11.03, 15.55 and 21.77% in HD-2329 in contrast to a loss of 8.24, 20.32, 26.16 and 38.54%, under similar conditions for PDW-215. PDW-215 had the lowest ash content of 1.20% after 120 sec debranning in spite of having the highest ash content of 1.953% in the whole grain. HD-2329 showed the lowest loss in ash content after 120 s of debranning. These differences among the cultivars may be attributed to variation in the removal of branny layers which are richer in ash content. Earlier studies have also indicated higher ash concentration in outer layers of grain than in endosperm (Morris *et al.*, 1946; Sekhon *et al.*, 1992*b*; Fares *et al.*, 1996). The weight of kernel removed at successive debranning levels indicated significant differences among the different cultivars. The PBW-343 cultivar had the lowest loss of 6.4% against the highest loss of 8.95% for PDW-215. These differences among cultivars are due to differences in hardness of grains. Durum wheat cultivars have been reported to have higher hardness than bread wheat (Singh *et al.*, 1990). Osuchowski and Bushuk (1980) reported that pearling of grain, to 65% yield, removed 43–87% of the bran ash. They also observed a greater portion of the ash removed by debranning in durum wheat and hard red spring wheat cultivars than soft wheat cultivars.

Table 2. Regression equation for relationship between debranning time and ash

Cultivars	Regression equation	R^2
HD-2329	Y = 1.690−0.002X	0.99
PBW-343	Y = 1.8470−0.003X	0.94
PDW-215	Y = 1.960−0.006X	0.99

X = ash content, Y = debranning time.

In order to explore the relationship between conductivity and ash contents, the conductivity of solubles extracted at 30°C and 50°C for 1 and 2 h and ash contents of all cultivars were fitted to a two-parameter straight line equation in the following form.

Table 1. Effect of debranning time on the ash content of different wheat cultivars

Debranning time (s)	HD-2329		PBW-343		PDW-215	
	Ash content (%)	Weight removed (%)	Ash content (%)	Weight removed (%)	Ash content (%)	Weight removed (%)
0	1.704[a]	—	1.866[a]	—	1.953[a]	—
30	1.577[b]	3.33[d]	1.716[b]	3.34[d]	1.792[b]	4.14[d]
60	1.516[c]	4.34[c]	1.68[c]	4.28[c]	1.556[c]	5.76[c]
90	1.439[d]	6.63[b]	1.67[d]	5.88[b]	1.442[d]	6.7[b]
120	1.333[e]	7.61[a]	1.476[e]	6.40[a]	1.20[e]	8.95[a]

Values with different letters differ significantly ($p \leq 0.05$).
Higher ranked letters are significantly different from lower ranked letters in the following order: a > b > c > d > e.

$$k = k^0 + SkA \quad (1)$$

where k^0 is the intercept (conductivity at zero ash content) and Sk is the slope. The conductivity showed a linear relationship with ash content in all cultivars with an R^2 value in the range of 0.93–0.99. Figure 2 illustrates the relationship between conductivity of solubles extrated for 1 h at 30°C and ash content in different cultivars. The equations in Table 3 showed that PDW-215 had higher k^0 values than PBW-343 and HD-2329 cultivars at all extraction temperatures and periods studied. This can be attributed to the presence of greater amounts of inorganic salts in PDW-215 than in HD-2329 and PBW-343 cultivars, which corroborated well with the measured ash contents. The k^0 value was strongly dependent upon the duration of extraction as well as the temperature at which the extraction was carried out. It increased with the increase in extraction time and temperature. The k^0 values were positive and higher for the extract at 50°C than those at 30°C for all cultivars. This suggested that greater amounts of inorganic salts could have been extracted with a longer extraction time and higher temperature. A similar conclusion can also be deduced from the variation in Sk values.

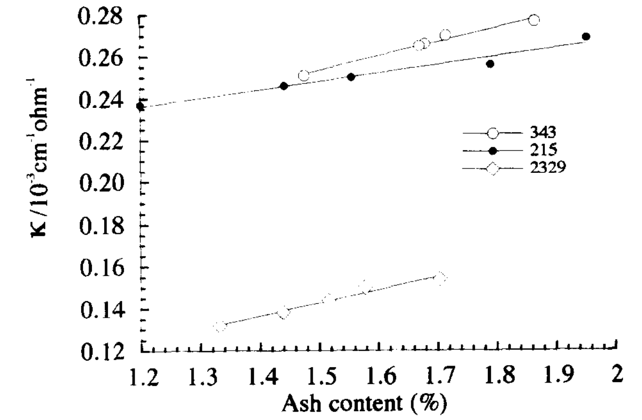

Fig. 2. Relationship between conductivity of solubles extracted for 1 h at 30°C and ash content for different cultivars.

Table 3. Regression analysis for relationship between ash content and conductivity

Cultivar	Extraction temperature (°C)	Extraction period (h)	Regression equation	R^2
HD-2329	30	1	Y = 0.049 + 0.062X	0.98
	30	2	Y = 0.096 + 0.050X	0.93
	50	1	Y = 0.048 + 0.081X	0.95
	50	2	Y = 0.122 + 0.077X	0.98
PBW-343	30	1	Y = 0.152 + 0.0678X	0.99
	30	2	Y = 0.208 + 0.068X	0.97
	50	1	Y = 0.149 + 0.081X	0.99
	50	2	Y = 0.187 + 0.011X	0.98
PDW-215	30	1	Y = 0.189 + 0.040X	0.98
	30	2	Y = 0.204 + 0.053X	0.99
	50	1	Y = 0.194 + 0.055X	0.99
	50	2	Y = 0.232 + 0.062X	0.99

X = Ash content, Y = conductivity.

Table 4. Regression analysis for relationship between k^0 and debranning time

Cultivar	Extraction temperature (°C)	Extraction period (h)	Regression equation	R^2
HD-2329	30	1	Y = 0.155–0.0002X	0.99
	30	2	Y = 0.180–0.0001X	0.91
	50	1	Y = 0.185–0.0002X	0.94
	50	2	Y = 0.252–0.0002X	0.98
PBW-343	30	1	Y = 0.277–0.0002X	0.94
	30	2	Y = 0.335–0.0002X	0.98
	50	1	Y = 0.299–0.0002X	0.95
	50	2	Y = 0.391–0.0003X	0.98
PDW-215	30	1	Y = 0.266–0.0002X	0.98
	30	2	Y = 0.309–0.0003X	0.98
	50	1	Y = 0.302–0.0003X	0.99
	50	2	Y = 0.354–0.0004X	0.99

X = k⁰, Y = debranning time.

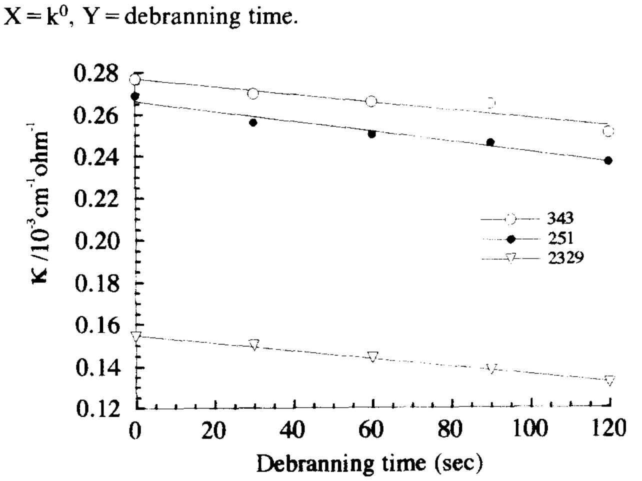

Fig. 3. Relationship between conductivity of solubles extracted for 1 h at 30°C and debranning for different cultivars.

Linear regression models for the relationship between conductivity and debranning time are reported in Table 4. The data were fitted to a linear equation similar to equation (1) in the following form.

$$A_C = A_C^0 + A_sB \quad (2)$$

where A_C^0 stands for the conductivity at zero debranning time and A_s is the slope. The variation in A_C^0 and A_s for each cultivar at a particular temperature was identical to that of k^0 and Sk, as mentioned above. As the debranning time increased, the conductivity of each cultivar decreased (Fig. 3). This inference supports above deduction that the ash content decreased with the increase in debranning time, due to which the conductivity progressively decreased.

CONCLUSION

Debranning of wheat using a McGill No. 2 rice polisher can be a useful technique to evaluate ash distribution in different wheat cultivars. The durum and bread wheat cultivars vary significantly with respect to ash distribution and weight of grain removed during debranning. Ash content showed a linear relationship with conductivity as well as debranning time in all the cultivars. The determination of ash content by conductivity measurement is a useful and quick method for the milling industry. However, during ash determination by conductivity, factors such as extraction temperature and time should be taken into account.

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