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SCIENCE DIRECT
Food Chemistry 100 (2007) 1316–1323
Food Chemistry
www.elsevier.com/locate/foodchem

Losses of nutrients and anti-nutritional factors during abrasive decortication of two pearl millet cultivars (*Pennisetum glaucum*)

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Received 15 August 2005; received in revised form 11 November 2005; accepted 11 November 2005

Abstract

Losses of nutrients such as starch, lipids, proteins, iron and zinc as well as phytase activity and of recognised anti-nutritional compounds (some insoluble fibres, iron-binding phenolic compounds and phytates) were determined following abrasive decortication of grains from two pearl millet cultivars (Gampela and IKMP-5) with different composition cultivated in Burkina Faso. In both cultivars, abrasion of the starchy endosperm started when about 12% of the dry matter had been removed from grains but lipid and protein losses followed the loss of dry matter. Zinc loss (%) was lower than that of iron; however, both were higher than dry matter losses. By contrast, phytate loss was lower than dry matter loss. Interestingly, decortication led to significant losses in fibres and iron-binding phenolic compounds with different level depending on the cultivar. Changes in phytase activity also differed in the two cultivars (42% and 11% losses of phytase activity in grains from Gampela and IKMP-5 cultivars, respectively, at 12% of abrasion). Hence, decortication of pearl millet grains does not decrease lipid and protein contents but does considerably decrease some anti-nutritional factors (part of the fibres and iron-binding phenolic compounds). However, as mineral contents and particularly iron content decreased while phytate content remains high, decortication may be insufficient to increase Fe and Zn bioavailability.

Keywords: Abrasive decortication; Anti-nutritional factors; Distribution in grain; Pearl millet

1. Introduction

Millets are indigenous African cereals that, unlike wheat or rice, are well adapted to African semi-arid and sub-tropical agronomic conditions. Millets grow under difficult ecological conditions and tolerate poor soils and a certain degree of drought better than any other cereal crops (Obilana, 2003). There are nine species of millet cultivated around the world and pearl millet (*Pennisetum glaucum*, synonyms: *P. americanum, P. typhoides*) is the most widely grown species in Africa. In 2001, 10.7 million tonnes of millet were produced in Sahelian Africa (Burkina Faso, Gambia, Mali, Niger, Nigeria, Senegal, and Chad). This represents in these countries an average of 495 kcal per person per day and up to 1014 and 609 kcal per person per day in Niger and Burkina Faso, respectively (FAO, 2004). Indeed, in many African countries, millet is often the main component of many meals and is essentially consumed as steam-cooked products (''couscous''), thick porridges (''Tô''), and thin porridges (''Ogi'') which can be used as a complementary food for infants and young children, and is also used in brewing beer (Obilana, 2003).

Pearl millet is nutritionally better than most other cereals; it has high levels of calcium, iron, zinc, lipids and high quality proteins (Klopfenstein & Hoseney, 1995). But, as in

Abbreviations: DM, dry matter; PC, phenolic compound; Cat., catechin; Tan., tannin.

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doi:10.1016/j.foodchem.2005.11.027

other cereal grains, nutritional quality is considerably lowered by the presence of anti-nutritional factors leading to poor digestibility of proteins, carbohydrates and minerals.

In developing countries, the low bioavailability of minerals (especially iron and zinc) in cereal-based foods is a crucial problem for infants and young children. The main anti-nutritional factors acting on iron and zinc bioavailability are phytates, certain phenolic compounds and fibres (Camara & Amaro, 2003; Gilloly et al., 1984).

Depending on their localization in cereal grain, the proportions of these anti-nutrients in diet can be reduced by decortication (Akingbala, 1991; Sharma & Kapoor, 1996), a process which may also modify mineral content and bioavailability. Some of the traditional products cited above necessitate preliminary decortication of grains for either organoleptic or technological reasons (astringency, texture, etc.). Although distribution of biochemical components in the different structures of cereal grains is well known for certain species such as wheat, maize or rice (Godon & Laignelet, 1991), research on pearl millet is poor. Only two studies give some results on the proportions of the anatomical parts of pearl millet grains and the distribution of some nutrients and phytates in these different parts (Abdelrahman, Hoseney, & Varriano-Marston, 1984; Simwemba, Hoseney, Varriano-Marston, & Zeleznak, 1984).

The objective of this study was to establish relationships between the level of abrasive decortication and losses of some major nutrients (starch, lipids, proteins, iron and zinc), anti-nutritional factors (certain fibres, iron-binding phenolic compounds and phytates) and phytase activity in the grains of two pearl millet cultivars from Burkina Faso in order to evaluate impact of this process on the nutritional value of pearl millet.

2. Experimental

2.1. Millet grains

Grains of two millet cultivars (*Pennisetum glaucum*) were obtained from the Environmental and Agricultural National Research Institute (INERA) of Ouagadougou (Burkina Faso). The Gampela cultivar (yellow in colour) is usually grown and consumed locally, whereas IKMP-5 (green in colour) is the result of agronomic improvements and has a better yield and nutritional quality.

2.2. Decortication process and preparation of samples

The initial water content of Gampela and IKMP-5 was, respectively, 7.8% and 9.3%; the moisture content of the grain samples of the two millet cultivars was adjusted to 15% to facilitate decortication. Samples were tempered at 20 °C in sealed plastic containers for 16 h in a rotary shaker (Reax 2, Heidolph, Schwabach, Germany) at 30 rpm. Grains were mechanically sieved to obtain grain samples with homogeneous diameters from 2.0 to 2.5 mm. Abrasive decortication was performed on 80 g of tempered samples with a laboratory huller (TM 050, Satake, Stockport, UK) at 750 rpm. After determination of dry matter (DM) content, the decorticated grains were freeze-dried and milled with a laboratory mill (IKA M20, Labortechnik, Staufen, Germany), sieved to pass through a 0.5 mm screen and stored at 4 °C for chemical analyses.

2.3. Analytical methods

Starch content was estimated by determination of glucose concentration using a colorimetric method (560 nm) after enzymatic degradation with α-amylase (EC 3.2.1.1) (Termamyl 120L, Novozymes, Bagsvaerd, Denmark) followed by amyloglucosidase (Fluka, 10115) according to Batey (1982) and Holmes et al. (1986) and using a conversion factor of 0.9. The results obtained also included mono- and disaccharides which were disregarded because they were only present in small quantities in raw cereal grains.

Protein content was determined according to the AFNOR NF V03-050 (1970) standard method (nitrogen content determination by Kjeldahl method) with a conversion factor of 6.25.

Lipid content was determined by HT6 Soxtec system (Tecator, Höganäs, Sweden) following the instructions in Tecator N° 3144.

Total iron and zinc contents were determined by atomic absorption spectrophotometry (SpectrAA 200, Varian, Victoria, Australia) after dry ashing as described by Laporte, Kovacsik, and Pinta (1980).

ADF fibre content, which corresponded approximately to cellulose and lignin contents, was determined according to the gravimetric method of Van Soest (1963) using a Dosi-fiber (Selecta, Barcelona, Spain).

Iron-binding phenolic compound content was determined according to the method of Brune, Rossander, and Hallberg (1989) using a ferric ammonium sulphate reagent which enabled measurement of galloyl (expressed as tannic acid equivalents) and catechol (expressed as catechin equivalents) group contents at two wavelengths (578 and 680 nm, respectively).

Phytate contents were estimated by determination of *myo*-inositol hexaphosphate (IP6) content obtained by anion-exchange HPLC separation according to the method of Talamond, Gallon, and Trèche (1998) with slight modifications (centrifugation after extraction carried out at 4500*g*, for 20 min at 4 °C and dilution of the residue before injection in 2 ml of deionized water).

Phytase activity was estimated using colorimetric determination of phosphorus released during incubation of phytase extract in a sodium phytate solution. Phytase was extracted from 2 g of flour in 20 ml of buffer at 4 °C according to the procedure of Konietzny, Greiner, and Jany (1995) with buffer modification (0.1 M acetate buffer, pH 5.6). The samples were magnetically stirred for 2 h at 4 °C and centrifuged at 10,000*g* for 30 min at 4 °C. The supernatants were shaken for 10 min with 1 g of AG

1-X8 anion resin (Bio-Rad Laboratories, Richmond, CA) to remove phosphorus and *myo*-inositol phosphates (Bergman, Autio, & Sandberg, 2000) and centrifuged again. The supernatants were used as enzyme extracts. Two milliliters of crude enzyme extract were incubated for 1 h at 30 °C with 2 ml of 2.5 mM sodium phytate solution (Sigma, P-8810) and 10 ml of 0.1 M acetate buffer at pH 5.6. The reaction was then stopped by adding 4 ml of 2 M HCl. Free Pi contents were measured by spectrophotometry on 0.25 ml of incubated solution according to the method of Heinonen and Lahti (1981). The results were calculated as mg of released Pi per hour by phytase extracted from 100 g DM of raw or decorticated grains, according to a standard range prepared with 5 mM KH_2PO_4 solution.

2.4. Calculation of extraction rates and component loss rates

Extraction rates of grain samples were calculated on a dry weight basis after each decortication experiment. Component loss rate was determined by subtracting to 100 the ratio (multiplied by 100) of the quantity of the component remaining after decortication on the quantity initially measured in the grains. For each component and each extraction rate, loss rates were calculated from each measurement (2 or 3 depending on the component) performed on decorticated grains in order to calculate means and standard deviation. As very few samples were analysed at each extraction rate, the data would not be suitable for rigorous statistical evaluation and hence would be only guideline information.

3. Results and discussion

3.1. Composition of the grains of pearl millet cultivars

Compositions of the grains of the two raw millet cultivars are given in Table 1. The starch contents of Gampela and IKMP-5 grains were not significantly different (70.1 and 69.3 g/100 g DM, respectively), nor were the lipid contents (5.58 and 5.77 g/100 g DM, respectively). It is interesting to note that the lipid content in millet grains was noticeably higher than in some other cereal species such as wheat or barley (about 1.8 or 2.1 g/100 g DM, respectively; Souci, Fachmann, & Kraut, 2000). By contrast, Duncan's test showed significant differences ($P \leqslant 0.05$) between protein, iron and zinc contents of the two cultivars. Indeed, IKMP-5 showed the highest values for all these nutrients, particularly iron (3.41 and 1.87 mg/100 g DM for IKMP-5 and Gampela, respectively). These differences could be due to the fact that IKMP-5 cultivar was obtained after varietal selection in agronomic stations. However, it is known that mineral contents are often more influenced by ecological conditions in the area where the crop is grown than by genetic factors as reported by Buerkert, Moser, Kumar, Furst, and Becker (2001) in their study of biochemical composition of pearl millet grain populations in Niger.

Table 1 also shows some differences in fibre contents with 2.48 and 4.23 g ADF fibres/100 g DM for Gampela and IKMP-5, respectively, and in iron-binding phenolic compound contents with 0.67 and 0.37 g catechin and tannin eq/100 g DM. Phytate contents were nearly identical with 0.72 and 0.80 g/100 g DM for the Gampela and IKMP-5 cultivars, respectively.

In our conditions (acetate buffer pH 5.6 at 30 °C), phytase activity of raw grains from Gampela cultivar was slightly higher than that of IKMP-5 (200 and 168 mg released H_2PO_4/h per 100 g DM, respectively).

3.2. Starch loss rate at decortication

Fig. 1 shows changes in starch loss rates as a function of the decortication rate (extraction rate) of grains from Gampela or IKMP-5 millet cultivars. The straight line ($y = x$) represents the expected theoretical loss of the nutrient if it was equally distributed throughout the grain tissues, respective to the decortication rate.

Table 1
Nutrient and anti-nutritional factor contents in whole grains from Gampela and IKMP-5 millet cultivars and calculated percentage of each compound removal after 12% grain decortication

	Gampela		IKMP-5	
	Content or activity in whole grain	Proportion (%) removed after 12% grain decortication	Content or activity in whole grain	Proportion (%) removed after 12% grain decortication
Starch (g/100 g DM)[a]	70.13 ± 0.68	3	69.30 ± 0.77	2
Protein (g/100 g DM)[b]	8.73 ± 0.10	13	10.11 ± 0.11	13
Lipids (g/100 g DM)[b]	5.58 ± 0.10	9	5.77 ± 0.09	10
Iron (mg/100 g DM)[b]	1.87 ± 0.04	27	3.41 ± 0.10	32
Zinc (mg/100 g DM)[b]	2.00 ± 0.02	18	2.57 ± 0.04	13
Fibre (g/100 g DM)[a]	2.48 ± 0.03	40	4.23 ± 0.10	56
Iron-binding PC (g cat. and tan. eq/100 g DM)[b]	0.67 ± 0.02	51	0.37 ± 0.01	19
IP6 (g/100 g DM)[b]	0.72 ± 0.04	4	0.80 ± 0.02	8
Phytase activity[a]	200 ± 8	42	168 ± 1	11

[a] Means ± standard deviation of 3 determinations (phytase activity expressed in mg released H_2PO_4/h per 100 g DM).
[b] Means ± standard deviation of 2 determinations.

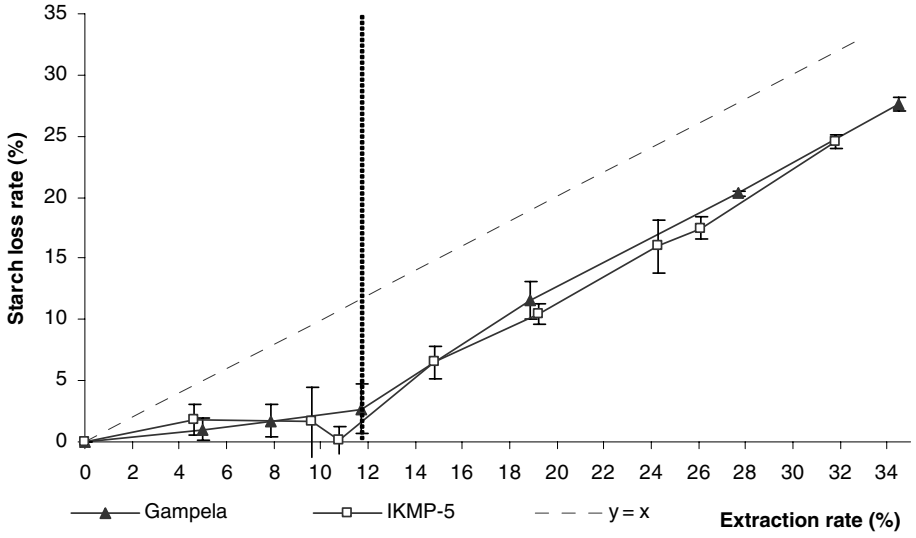

Fig. 1. Changes in starch loss rates during decortication of grains from Gampela and IKMP-5 millet cultivars. Vertical bars represent standard deviations of means based on three measurements. The straight vertical line marks the 12% extraction rate corresponding to the beginning of the starchy endosperm abrasion.

No starch loss was observed up to around 12% of DM extraction for both millet cultivars (Fig. 1 and Table 1). Abrasion of the starchy endosperm thus started only after the removal of about 12% DM. From 12% of extraction, starch loss was observed to progress linearly indicating that starch was uniformly removed from the grains.

The very limited loss in starch at the beginning of decortication is in agreement with the observations of De Francisco, Shepherd, Hoseney, and Varriano-Marston (1982) in their study about decortication of grains of pearl millet and sorghum cultivars. These authors showed that the pericarp of millet grains was removed in small flakes detached at the junction between the endosperm and the aleurone layer, whereas that of sorghum was removed in large flakes detached from the starch containing mesocarp. This characteristic of the millet pericarp could be due its higher thickness than that of sorghum. Furthermore, it is also recognised that grains with highly vitreous endosperm yield the highest endosperm recovery, whereas grains with floury endosperm yield the highest percent of broken grains (Murty & Kumar, 1995). Fig. 1 shows nearly identical starch losses profile along decortication of grains from the two studied pearl millet cultivars indicating that they probably have similar pericarp thickness and endosperm vitreousness.

3.3. Lipid and protein loss rates during decortication

The curves of lipid (Fig. 2A) and protein (Fig. 2B) loss rates of both cultivars were both found proportional to DM losses with a slight increase from around 12% of extraction, particularly for protein losses. Thus, as observed for starch, no difference was found between lipid and protein loss rates between the two cultivars. At 12% of DM loss, which corresponds to the weight grain removed before that the starchy endosperm started to be abraded, 13% of total protein and 10% of total lipid contents had been removed from grains of both cultivars (Table 1). According to Abdelrahman et al. (1984) studying American pearl millet cultivars, proportion of bran (including pericarp and aleurone) is comprised between 7% and 12% of the grain weight and corresponds, respectively, to 9% and 6% of total protein and lipid content of the grains. Hence, even if the cultivars described in our study are different from those of Abdelrahman et al., results indicate that part of the germ may started to be abraded with the outer layers. Indeed, visual observation of decorticated grains showed an abrasion of germ and the differences in protein (13% vs 9.4%) and lipid (10% vs 6.4%) contents of the removed non starch containing part can also be explained by the presence of germ, which contains higher amounts of proteins and lipids than the outer layers. The loss of germ at the beginning of decortication can be explained by the ovoid shape of the grains which makes the lower part of the germ vulnerable to abrasion. However, this loss appeared to be rather low and changes in starch loss rates showed that decortication as performed in our study allows the outer layers to be satisfactorily separated from the rest of the grain. This can be attributed to the tempering of grains which was already reported to allow easier decortication (Scheuring, Sidibe, Rooney, & Earp, 1983) and recovery of most of the protein and ash in mechanically abraded sorghum grains (Lochte-Watson, Weller, & Jackson, 2000).

3.4. Iron and zinc loss rates during decortication

Changes in iron and zinc loss rates along decortication of the grains from the two millet cultivars are shown in Fig. 3. At the beginning of decortication and until the starchy endosperm abrasion, iron losses were important and higher than those of zinc in both of the cultivars and then became more or less proportional to DM losses.

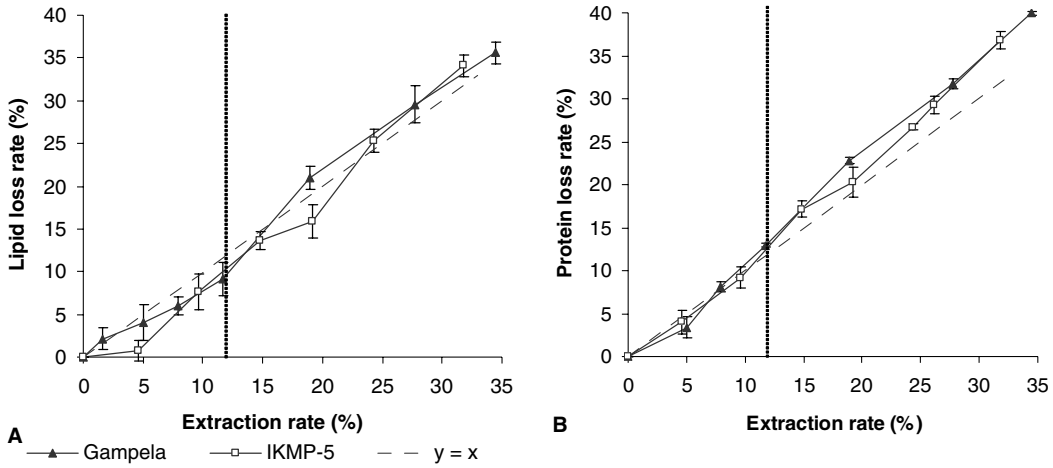

Fig. 2. Changes in lipid (A) and protein (B) loss rates during decortication from grains of Gampela and IKMP-5 millet cultivars. Vertical bars represent standard deviations of means based on two measurements. The straight vertical line marks the 12% extraction rate corresponding to the beginning of the starchy endosperm abrasion.

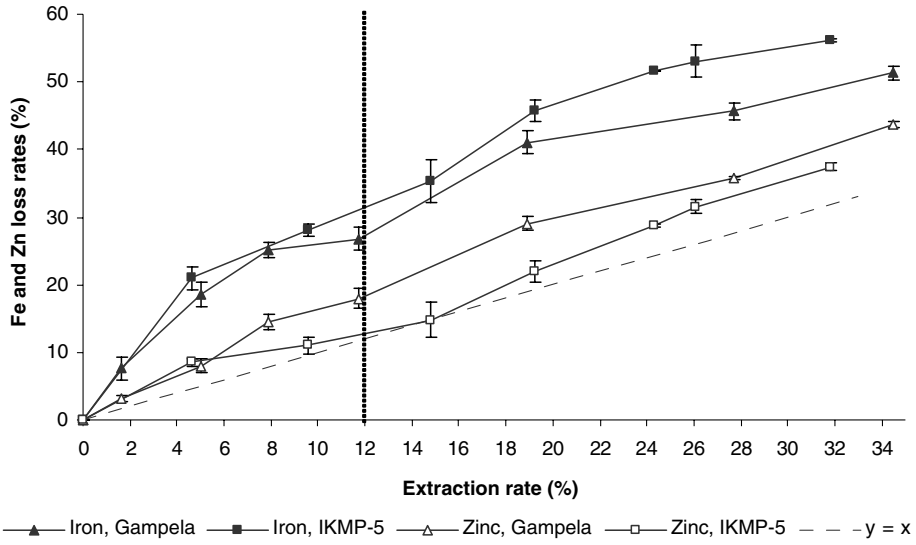

Fig. 3. Changes in iron and zinc loss rates along decortication of grains from Gampela and IKMP-5 millet cultivars. Vertical bars represent standard deviations of means based on two measurements. The straight vertical line marks the 12% extraction rate corresponding to the beginning of the starchy endosperm abrasion.

At 12% of extraction, around 30% of iron were lost from both of the cultivars (Table 1). As total iron content of IKMP-5 raw grains was about twice as high as Gampela (3.41 and 1.87 mg/100 g DM, respectively), the additional iron in grains of the IKMP-5 cultivar is probably distributed in the same way as in Gampela grains. Therefore, about one third of total iron is located in bran of pearl millet grains.

Zinc is more uniformly distributed in the different structures of the grains of both cultivars and around 15% is located in the outer layers (Table 1). Indeed, zinc is found in a large number of enzymes and other proteins (Cakmak, 2000; Cobbett & Goldsbrough, 2002), where it plays an important structural role and must therefore be linked to protein losses which were already found proportional to DM losses. However, it appears more rapidly removed from Gampela than from IKMP-5 despite a lower total amount.

3.5. Fibre and iron-binding phenolic compound loss rates during decortication

Curves in Fig. 4A shows that half of the ADF fibres can be removed by abrasion of 10% to 20% of the grain DM. ADF fibres were eliminated slightly faster from IKMP-5 than from Gampela grains, but shape of the two curves appears nearly identical. Indeed, at 12% of DM extraction, 56% and 40% of total ADF fibres was removed from IKMP-5 and Gampela cultivars, respectively (Table 1).

By contrast, curves representing iron-binding phenolic compounds (PC) loss rates (Fig. 4B) display important differences. Iron-binding phenolic compounds losses from IKMP-5 grains remain low at the beginning of decortication and increased between around 5% and 15% of extraction to become proportional to DM loss. The iron-binding

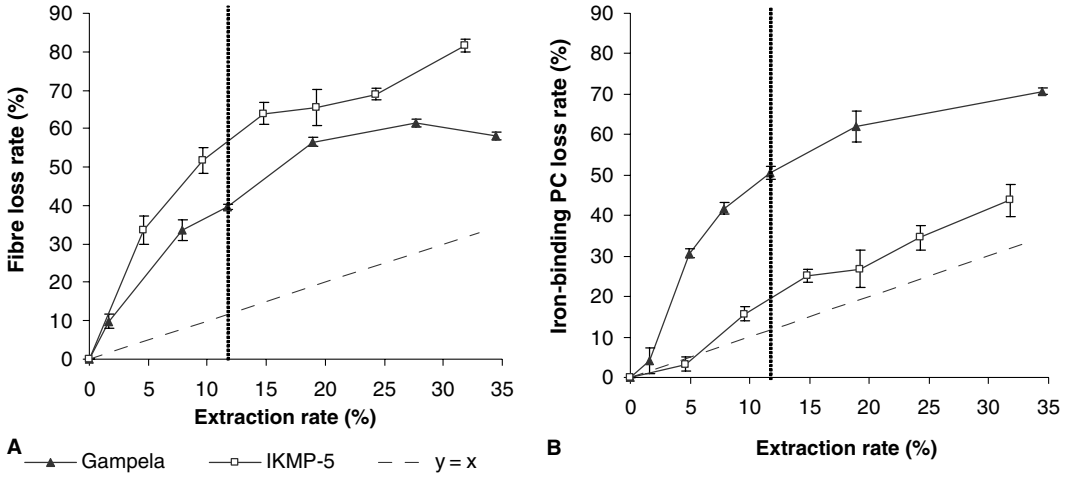

Fig. 4. Changes in ADF fibre (A) and iron-binding phenolic compound (B) loss rates along decortication of grains from Gampela and IKMP-5 millet cultivars. Vertical bars represent standard deviations of means based on three and two measurements, respectively. The straight vertical line marks the 12% extraction rate corresponding to the beginning of the starchy endosperm abrasion.

PC loss rate from Gampela grains was very high at the beginning of decortication but slowed down from around 8% of extraction. Therefore, until the beginning of starchy endosperm abrasion, 19% and 51% of the total iron-binding PC were, respectively, removed from IKMP-5 and Gampela cultivars (Table 1).

These differences may be due to the distinct composition of the two cultivar outer layers which in turn is probably due to differences in contents of raw grains (Table 1). Indeed, ADF fibre content of IKMP-5 was higher than that in Gampela (4.23 vs 2.48 g/100 g DM) whereas, iron-binding PC content in Gampela cultivar was higher than that from IKMP-5 (0.67 vs 0.37 g/100 g DM) indicating that most part of this additional quantity of fibers and iron-binding PC are located in bran.

Our results agree with those of Serna-Saldivar, Clegg, and Rooney (1994) who reported that pearl millet decortication led to an important reduction in insoluble fibre content (from 6.30 to 3.55 g/100 g DM after decortication at 17.5% of extraction). Concerning iron-binding PC losses, the effect of decortication on total polyphenol content of grains from two pearl millet cultivars cultivated in Sudan was already described by El Hag, El Tinay, and Yousif (2002) who reported a decrease of 22.4–26.4% following dehulling. However, the extraction rate was not indicated in this case.

Thus, even if different amount of fibres and iron-binding PC are found in grains of the two cultivars, decortication appears as a relevant process to reduce their quantity. Furthermore, it appears that, in pearl millet grains; iron-binding PC are not always associated with fibres as their proportions in peripheral parts of the grains are different in the two cultivars.

3.6. Phytate and phytase loss rates during decortication

Fig. 5A shows changes in phytate loss rates in grains from the two cultivars along decortication. Observed curves indicate that phytate loss rates in both of the pearl millet cultivars remain low at the beginning of decortication and are under 10% even at 20% of DM removal when starchy endosperm began to be abraded. Then, phytate loss rate increase to become proportional to DM loss rates in Gampela grains. Thus, it appears that phytates are mainly distributed in starchy endosperm and germ. Simwemba et al. (1984) showed that phytate content of pearl millet grain was 752 mg/100 g in germ against 86 and 278 mg/100 g for endosperm and bran, respectively. Taking these values with those reported by Abdelrahman et al. (1984) for the proportions of the different grain structures, about 60% of the phytates appeared to be located in germ, 30% in the endosperm and 10% in the bran fraction. Even if these above studies were made with American cultivars, our results appear in accordance to this phytate repartition as only 4% and 8% of the phytates was removed from grains of Gampela and IKMP-5 cultivars, respectively, at 12% of DM extraction (Table 1).

Differences in phytase activity loss rate curves of the two millet cultivars were observed as reported in Fig. 5B. In grains from the Gampela cultivar, the loss in phytase activity was high at the beginning of decortication and reached 42% at 12% of DM extraction (Table 1) and then slowed down. This result suggests that phytases are mainly located in the outer layers in this cultivar. By contrast, the loss in phytase activity corresponded to DM loss in grains from the IKMP-5 cultivar from 0% to 32% of extraction, and thus fits protein losses (Table 1). This indicates differences in the distribution of phytase activity in grains from the two cultivars although similar distribution of phytates was observed. However, as the level of phytase activity in Gampela grains was slightly higher than that in IKMP-5, the activity of the decorticated grains was about the same for the two cultivars at 12% of DM extraction. A different distribution of phytase activity between the different parts of the grains was already described in barley by Bergman et al. (2000). Indeed, these authors showed that degradation of phytates was higher in the scutellum cells of the

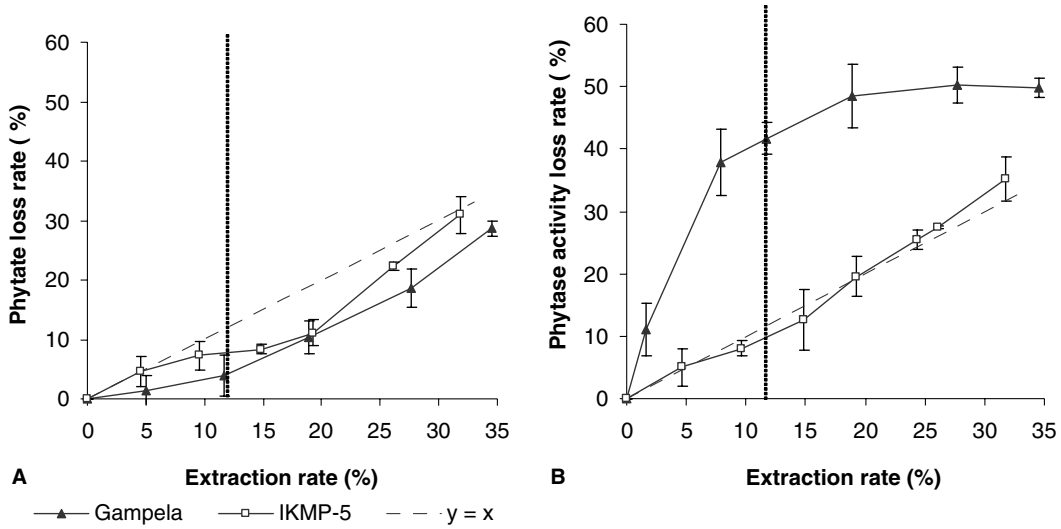

Fig. 5. Changes in phytate (IP6) (A) and phytase activity (B) loss rates during decortication of grains from Gampela and IKMP-5 millet cultivars. Vertical bars represent standard deviations of means based on two and three measurements, respectively. The straight vertical line marks the 12% extraction rate corresponding to the beginning of the starchy endosperm abrasion.

germ than in the aleurone layer, a result that was also found in wheat grains by Peers (1953). Thus, precise location of phytates and endogenous phytases in millet grain tissues will be interesting to determine to better describe nature of the removed tissues and grain behaviour at decortication.

3.7. Effect of decortication on the nutritional value of pearl millet

Table 1 summarizes losses of each of the nutritional component analysed in this study at 12% of DM extraction. Protein and lipid contents were not changed by decortication as shown by the observed protein and lipid loss rates close to those of DM loss. As far as minerals are concerned, although zinc content did not change to any great extent, particularly in grains from the IKMP-5 cultivar, iron content decreased significantly by about one third. At the same time, phytate content remains high following decortication as less than 10% of phytate was removed from grains of both cultivars. Consequently, the molar ratios of phytate to iron (Phy/Fe) and phytate to zinc (Phy/Zn), for which values higher than 10–15 was reported to decrease iron and zinc absorption (Davies & Olpin, 1979; Saha, Weaver, & Mason, 1994), increased after decortication (Phy/Fe: from 33 to 44 and 20 to 25, Phy/Zn: 35 to 42 and 30 to 32 for Gampela and IKMP-5 cultivars, respectively). However, certain fibres and PC were also reported to inhibit mineral absorption (Gilloly et al., 1984). Analysis of the decorticated grains clearly points out a significant reduction in ADF fibres and iron-binding PC contents following decortication. Thus, as the relative contribution of these anti-nutritional factors (phytates, fibres, iron-binding phenolic compounds) in reducing iron and zinc bioavailability has not been clearly established for millet grains, it is difficult to conclude about the ability of decortication to improve mineral bioavailability in millet grain. Furthermore, a decrease in phytase activity was also observed in the grains of one of the two cultivars, which suggests it will be more difficult to improve mineral bioavailability by conventional processes applied after decortication, such as soaking or fermentation, which usually enable phytate degradation by endogenous phytases. However, recent examination of iron and zinc availability using in vitro simulations of gastro-intestinal digestion performed on pearl millet flour samples containing different proportions of anti-nutritional factors (Lestienne, Besançon, Caporiccio, Lullien-Pèlerin, & Trèche, 2005) showed that if phytates are involved in reducing minerals availability, fibers and PC also play a role in this decrease. Therefore, decortication could contribute to reduction of unwanted compounds as part of the process.

4. Conclusion

Abrasive decortication at 12% DM extraction of pearl millet grains, after tempering to 15% of water content, led to efficient separation of the outer layers from the starchy endosperm and to a slight abrasion of the lower part of the germ in both of the cultivars studied. At this abrasion level, the starchy endosperm was not damaged and removal of the outer layers was shown to lead to reduce ADF fibre but also iron contents from both cultivars. In Gampela cultivar, reduction of iron-binding PC and phytase activity were also observed. Protein, lipid and zinc contents were not changed to a great extent following decortication as these compounds appeared uniformly distributed in pearl millet grains. Phytate content in grains from both cultivars remained high after decortication at 12% of DM extraction as it is mainly located in germ and endosperm. Thus, decortication must be coupled with another process in order to

improve nutritional value of pearl millet, and particularly iron and zinc bioavailability.

Acknowledgments

The authors thank INERA of Ouagadougou for providing grains of pearl millet cultivars, M. Chaurand (INRA, Montpellier) and I. Rochette for technical assistance with laboratory hulling and HPIC analyses of phytate, respectively. Our thanks to C. Icard-Vernière and J.P. Guyot for their advice.

This work is part of the Cerefer project (www.mpl.ird.fr/cerefer) funded by the European Commission Contract No. ICA4-CT-2002-10047.

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