Crib orientation and initial moisture content effects on storage loss indices of dehusked maize (var. *Okomasa*) in an improved crib

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ABSTRACT

An investigation was conducted into the storage loss indices of maize (*Zea mays* L. var. *Okomasa*) with initial moisture contents 18, 26, and 32 per cent (w. b), in two sets of improved cribs, with longitudinal faces parallel and perpendicular to the prevailing wind, from September to February for 2 years. Storage indices studied were the cumulative percent weight loss, drying rates, insect and fungal damage, and changes in free fatty acid contents. There were no significant ($P > 0.001$) differences between the cumulative percent weight loss of maize in the two sets of cribs. Though drying of maize in the crib with long face perpendicular to wind was initially faster, the drying rates became uniform by the end of the 2nd month of the storage. Insect and fungal damage (mouldiness), and changes in free fatty acid content were negligible. Thus, the overall quality of maize harvested at moisture contents 18-32 per cent and stored in an improved crib are comparable.

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RÉSUMÉ

JOHNSON, P.-N. T.: *L'orientation de crib et les effets du contenu d'humidité initiale sur les indices de perte en stockage de maïs (var. Okomasa) décortiqué dans un crib amélioré*. Une enquête des indices de perte en stockage de maïs (*Zea mays* L. var. *Okomasa*), avec les contenus d'humidité initiale de 18, 26 et 32 pour cent (w. b), par deux séries de crib amélioré, avec les côtés longitudinales parallèles et perpendiculaires au vent dominant, s'est déroulée du mois de Septembre à Fevrier pour 2 ans. Les indices de stockage étudiés étaient le pourcentage cumulatif de la perte de poids, la vitesse de séchage, l'insecte, les dégâts fongiques et les changements de contenus d'acide gras libre. Il n'y avait pas de différences considérables ($P > 0.001$) entre le pourcentage cumulatif de la perte de poids du maïs dans les deux séries de crib. Malgré le fait que le séchage de maïs dans le crib de côté longue perpendiculaire au vent ait été initialement plus vite, la vitesse de séchage devenait identique à la fin de la 2[e] mois du stockage. L'insecte, les dégâts fongiques (la moisissure) et les changements du contenu d'acide gras libre étaient négligéables. Ainsi, l'ensemble de qualité de maïs moissonné à des contenus d'humidité de 18 à 32 pour cent et stocké dans un crib amélioré sont comparables.

Introduction

Reduction of post-harvest losses in the maize industry in Ghana has mainly involved improving methods and practices used in on-farm drying and storage of maize. The use of the improved crib, with its width between 60 and 100 cm, height of platform 100 cm and 50 per cent wall openings, has been recommended to the small-scale farmer (FAO, 1980). The moisture content of maize at harvesting is usually around 20-22 per cent (w. b). Maize, with husk and harvest moisture content above this range, usually does not dry well when stored closely packed. The level of fungal damage in such situations could be very high, especially during prolonged raining seasons (FAO, 1980). Sometimes, the weather pattern in a particular year becomes unpredictable, with the heavy rains of May to July not being followed immediately by the usual short spell of dry weather with sufficient sunshine in August and September, when harvesting is taking place. Instead, the rains keep falling all through the latter months. The initial moisture content of freshly harvested maize may be well above 22 per cent (w. b).

One other important requirement of the improved crib is that its axes must be perpendicular to the prevailing wind direction (FAO, 1980). This can best be achieved if the crib is positioned outside the living compound of the farmer, where it will be fully exposed to the prevailing wind in the area. However, because of the fear of theft and other socio-economic reasons, most Ghanaian maize farmers feel reluctant to locate their maize cribs outside their living compounds. When that happens, the positioning of the crib may not be the best to facilitate easy drying of maize, especially if moisture content is above 22 per cent (w. b).

This study, therefore, investigated the extent and significance of storage losses of maize initially at a relatively high moisture content and stored in an improved crib in a non-ideal position. This study, replicated twice, was carried out between the months of September and February.

Materials and methods

The experimental cribs

Two sets of three improved cribs, each measuring 3.0 m long, 1.0 m wide, 1.2 m high and having 50 per cent wall-slat openings (FAO, 1980), were used. The first set of three cribs, the control cribs, were positioned in such a way that the eastern and western sides of these cribs were fully exposed to the sun in the morning and afternoon, respectively. By this arrangement, their longitudinal axes were perpendicular to the prevailing wind direction at the site, which was north to southernly for most of the time. The second batch of three cribs, which formed the test cribs, had their long axes parallel to the prevailing wind direction. Each crib was divided into two storage compartments serving as replicates. The two sets of cribs were thoroughly cleaned and disinfected with the insecticide primiphos-methyl (Boshoff, 1977). Each replicate storage compartment held about 240 kg of dehusked maize of the same moisture content. This is about equal to 156 kg of shelled maize at 13.0 per cent (w. b) moisture content.

Source and sampling of stored maize

Maize was obtained from a commercial maize grower. The moisture contents of maize on six field plots were periodically monitored just before maturity, with a portable capacitance-type moisture meter (DjGMT 052847514), until the desired moisture content of 32, 26, and 18 per cent (w. b) were obtained from randomly sampled maize ears. The maize ears were randomly harvested, loaded into appropriately labelled jute sacs and transported same day to the project site, the Pilot Plant Section of the Food Research Institute, Accra. Maize ears having the same harvest moisture content were pooled together and dehusked, with the few bad ones sorted out. The dehusked maize was pre-treated with the same insecticidal treatment as given to the cribs. Maize was sampled randomly from the top, sides, and mid-sections of the crib (Ofosu, 1987). The sampled cobs from each replicate were reduced to about 100 cobs by conning and quartering (Golob, 1984). The sampled cobs were immediately shelled and the sample grains were analysed.

Measurement and analysis

Drying rate was determined by the following changes in moisture content (AACC, 1983). Drying curves were constructed and the relative drying rates estimated by the method of slopes (Toledo, 1991). Daily measurements of temperature and relative humidity around the cribs were monitored by using a thermo-hygrometer (model HTAB, Abbeon Cal Inc.), wind speed by an anemometer (Negretti & Zambra, London), and intensity of insolation by a portable luxmeter (BDH, London). All measurements were carried out in the mornings (8.30 and 12.30 h) and afternoons (13.30 and 15.30 h). Loss was assessed by the methods of Ofosu (1987). The changes in the thousand grain mass (TGM) loss and cumulative percent weight loss were calculated. The reliability of the TGM loss values was assessed by using the coefficient of variation percentage (Proctor & Rowley, 1983). The changes in free fatty acid contents were determined at 2-week intervals (AACC, 1983). Fungal damage was assessed according to the methods of Harrigan & McCance (1976). The ELISA method (AgriScreen, Neogen, USA) was used to screen for the presence of aflatoxins in each sample.

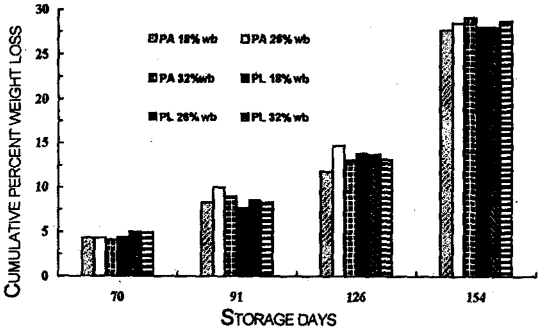

Fig. 2. Cumulative percent weight loss of maize (var. *Okomasa*), initially of three different moisture content, stored in two sets of cribs with long faces perpendicular (PL) and parallel (PA) to the prevailing wind.

Results and discussion

Drying of maize-on-cob stored in a crib depends on the width of the crib, the ambient conditions (temperature, rainfall, and relative humidity), the gaps between the wall partitions, and the velocity of air flow through the crib (FAO, 1980; Golob *et al.*, 1983). The difference in orientation of the two sets of cribs was probably the main variable which influenced the velocity of air flow through the cribs. This should have affected the overall rate at which moisture was carried away from the stored maize and, therefore, the cumulative percent weight loss (FAO, 1980). Though initial drying rates of maize (26 and 32 per cent w.b) in cribs with long faces perpendicular were slightly faster compared to those in cribs with faces parallel to the wind (Fig. 1), this did not significantly affect the overall cumulative percent weight loss (Fig. 2). This indicates that the overall drying processes in the two sets of cribs during the 150-day storage period were comparable, especially as shown after the 60th day (Fig. 3). Several factors could account for this, one of which might be due to the differences in the weather in the mornings as compared to those in the afternoons over September/October during the storage period. During these periods, the weather was characteristically cloudy in the mornings with sunny intervals primarily confined to the afternoons.

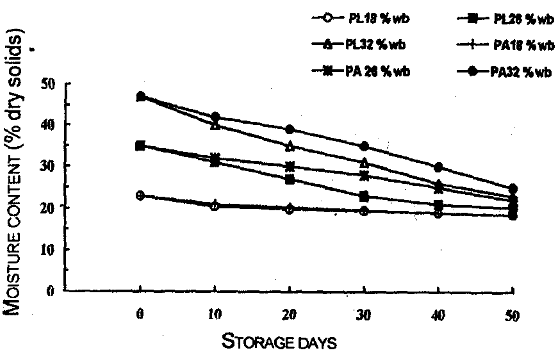

Fig.1. Drying curves for the 1st fifty days of maize (var. *Okomasa*), initially of three different moisture content, stored in two sets of cribs with longitudinal faces perpendicular (PL) and parallel (PA) to the prevailing wind.

Average intensities of insolation recorded during the mornings (8.30 to 12.30 h) and afternoons (13.30 to 15.30 h) of these periods were 1.4 and 2.8 MJ/m^2/h, respectively. These appear to have affected the ambient temperature (Fig. 4 and 5). The difference in temperature ranging from 2 to 3 °C on the eastern sides over that of the western sides is usually associated with the development of air currents (FAO, 1980). The direction of these air currents may sometimes change because of terrestrial heating. This normally occurs between 13.00 and 14.00 h when there is the greatest tendency for hot air on the surface of the ground to rise (Barry & Chorley, 1995). Uniform aeration and drying of stored maize will depend on the speed and, therefore, the

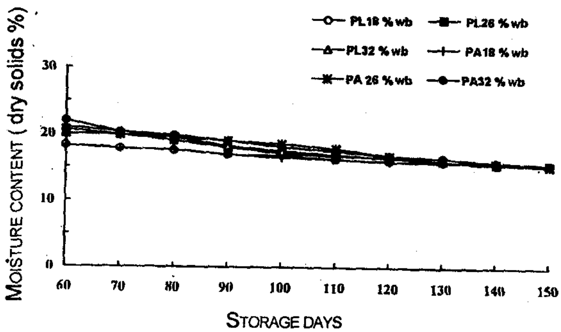

Fig. 3. Drying curves from the 60th day to end of storage of maize (var. *Okomasa*), initially of three different moisture content, stored in cribs with longitudinal faces perpendicular (PL) and parallel (PA) to the prevailing wind.

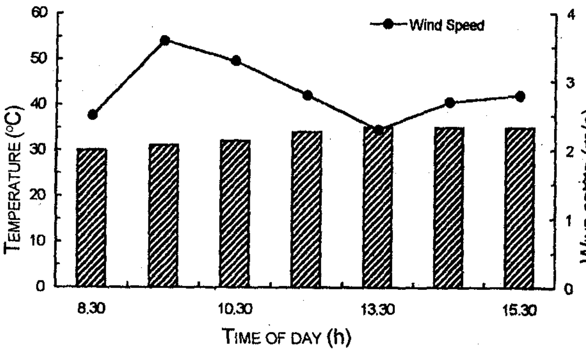

Fig. 4. Ambient temperature and wind speed on the eastern side of the set of cribs with faces perpendicular to the prevailing wind.

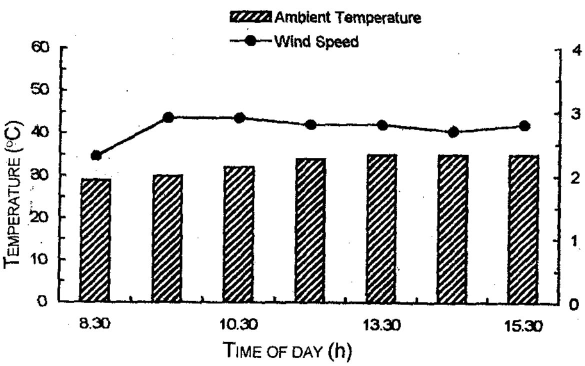

Fig. 5. Ambient temperature and wind speed on the western side of the set of cribs with faces perpendicular to the prevailing wind.

ability of these air currents to penetrate the improved crib in the hotter afternoons (FAO, 1980).

Though the test cribs had their long faces parallel to the normal wind direction, there were no buildings immediately around them. There were adequate spaces around and, therefore, the prevailing air currents were not obstructed in any way. This meant that the normal extent of aeration in the test cribs was probably comparable to that in the control cribs. Another likely factor was the relative drying in the two sets of cribs in the afternoon when the sun was on the western side of the cribs. During this time of the day, the long faces of the test cribs were fully exposed to the sun compared to the width ends of the control cribs. Thus, the effect of temperature on the drying of maize in the test cribs might have been more pronounced than that of the maize in the control cribs in the afternoons. During the period from December to January, the strong harmattan winds must have accelerated the drying process.

Maize classified as unfit for human consumption was damaged by insects, *Ephestia, Sitophilus,* and *Sitotroga* spp. Percentage weight loss of stored maize, from grains considered unfit for human consumption, is higher if the maize is stored with the husks compared to maize stored without husks (Ofosu, 1987). There was no evidence of mould growth and aflatoxin contamination.

Fig. 6 also supports the results in Fig. 2. It indicates that storage conditions within the two sets of cribs with their long faces parallel and perpendicular to the prevailing wind were comparable, and, therefore, did not favour the breakdown of fats. The absence of any detectable mouldiness in the samples is in line with the absence of aflatoxin (Christensen & Kaufmann, 1974). These results mean farmers who may be compelled to harvest maize with relatively high initial moisture content of 32 per cent (w. b) and store in an improved crib situated in a non-optimal position can still be

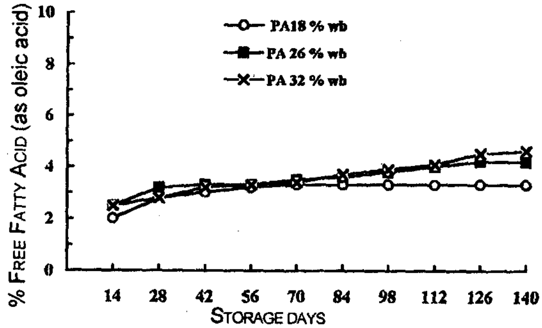

Fig. 6. Percent free fatty acid contents of maize (var. *Okomasa*), initially at different harvest moisture content and stored in narrow crib with longitudinal face parallel to the prevailing wind.

assured of storage losses not significantly different from maize initially at 18 per cent (w. b).

The adoption rate of the improved crib in Ghana has not been very encouraging, although several attempts were made in the last few years by the Ministry of Food and Agriculture, aided by various organizations, to extend the technology of the improved crib. It may well be that the insistence on farmers to position their cribs outside their living compounds to ensure that the cribs' longitudinal faces are perpendicular to the prevailing wind has been entirely unacceptable to most farmers for reasons stated earlier. The promotion of the improved crib must stress more on the reduction of the width to between 60 and 100 cm, using the dimensions close to 60 cm in situations where the crib has to be situated inside living compounds of the farmer where there is a reduction in air currents. A high percentage of maize farmers in Ghana still continue to use the traditional Ashanti crib with its width longer than one metre. Producers of traditional maize products in Ghana have expressed concern about the poor-quality maize on the Ghanaian markets during seasons when the weather is unfavourable for adequate on-farm drying (Johnson & Halm, 1998). Most of these have resulted from improperly dried stocks of maize.

Conclusion

The study has shown that during storage of dehusked maize, with initial moisture content as high as 32 per cent (w. b), in an improved crib, the orientation of the long face of the crib to the wind could have little effect on the overall quality. However, the crib must be situated at a site where there are no obstructions to air currents in the area.

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