CORRELATIONS AMONG BIOACTIVE COMPOUNDS IN SORGHUM GRAINS AND THEIR IMPACT ON AGRONOMIC AND FOOD QUALITIES

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INTRODUCTION

As illustrated by the presence of several thousands of sorghum germplasms, sorghum is genetically very diverse. It is a challenge to screen for biochemical markers in sorghum varieties, which can serve as determinants for sorghum grain quality for food processing (Dicko et al, 2006a). Biochemical markers for food-quality, such as phenolic compounds and enzymes involved in their biosynthesis and their oxidation and the reserve polysaccharide starch and its hydrolytic enzymes were investigated (Dicko et al. 2006b). Sorghum varieties display antioxidant activities that are comparable to those of the most important sources such as blackberries (Dicko et al. 2005a). A peroxidase, which is of importance for (bio)chemical, clinical and biocatalytic industries and also for the protection of environment has been isolated and characterized from sorghum grain (Dicko et al., 2006c). Furthermore, sorghum phenolic compounds and their oxidative enzymes can serve as makers for the grain preservation and even the whole plant resistance to biotic and abiotic stresses (Dicko et al., 2005b). This contribution reviews the current advances in sorghum biochemical screening, with emphasis on nutritional and health aspects. The potential utilization of sorghum in developing as well as in developed countries is discussed. This may provide some guidance for researchers in further investigations and for industries in developing functional foods.

Inter-relations between biochemical markers and food quality

As illustrated by the presence of several thousands of sorghum germplasms, sorghum is genetically very diverse. Therefore, it was a challenge to select a representative number of sorghum varieties cultivated in Burkina Faso to screen for biochemical markers, which can serve as determinants for sorghum grain quality in food processing. In this study, biochemical markers for food-quality, such as phenolic compounds and enzymes involved in their biosynthesis (phenylalanine ammonia lyase) and their oxidation (polyphenol oxidases and peroxidases), and the reserve polysaccharide starch and its hydrolytic enzymes (amylases) were investigated. Since germination influences the biochemical composition of the grain, the effect of germination on these markers was also assessed. As shown in Figure 1, the relationships between the screened biochemical markers may give directions for the selection of sorghum varieties for specific foods.

In tô preparation, the formation of a thick paste linked to high amylose content is necessary. Low α-amylase activity found in varieties good for tô is beneficial to obtain a relatively stick porridge. In analogy with what was found in wheat dough (Hilhorst et al., 1999), peroxidase may mediate the thickness of sorghum flour during tô preparation by cross-linking of carbohydrates containing endogenous hydroxycinnamate derivatives. Sorghum varieties with low viscosity are desired in the formulation of weaning foods with high energy density. In that case low amylose content and high α-amylase activities are determinant. For infant porridges, low tannin (referred as proanthocyanidins) containing varieties and low oxidase activities may be more convenient by avoiding enzyme-mediated oxidation of endogenous phenolic compounds into colored products. Interestingly, sorghum varieties rich in tannins can be suggested to obese people and diabetic patients by analogy with the 50% weight loss observed with animals (rabbits, pigs, etc.) fed with sorghums containing high levels of tannins (Ambula et al, 2001). This is supported by the observation that in certain cultures in Africa, people prefer to consume tannin containing sorghums because they have a longer "staying power" in the stomach (Awika and Rooney, 2004). The low digestibility of high tannins containing sorghums through the inhibition of hydrolytic enzymes, together with their high antioxidant activities (Dicko et al. 2005a) may be interesting from a nutritional standpoint for obese persons. Sorghum varieties display high antioxidant activities (30-80 µmol of Trolox equivalents/g) that are comparable to those of the most important sources such as blackberries. For dolo and industrial beer preparations, high α-amylase and β-amylase activities are desired. In industrial brewing, a specific interest exists in high β-amylase-containing sorghum varieties because this enzyme is usually lacking in sorghum. It is shown that some sorghum varieties contain β-amylase activities comparable of that of barley (Dicko et al., 2006b). These varieties can be suggested for industrial brewing. A constraint in the utilization of sorghum for industrial brewing is the high starch gelatinization temperature. Since amylose has a higher gelatinization temperature than amylopectin, sorghum with low amylose content could be targeted for industrial brewing. Low oxidase activities to avoid beer darkness and haze occurrence by the oxidation of endogenous phenolic compounds are other criteria for selection of sorghum for industrial brewing. For couscous preparation, the formation of a gel, mediated by peroxidase via the cross-linking of macromolecules, is not desired. In addition, low α-amylase activity is required to avoid starch dextrinization during the process. Acceptable bread can be produced with 30-50% sorghum substitution for wheat (Carson et al., 2000). Addition of sorghum flour possessing high peroxidase activities (Hilhorst et al., 1999) in combination with suitable α-amylase activity could lead to the cross-linking of sorghum glucuronoarabinoxylans. These polysaccharides are known to contain ferulic acid and may make addition of a higher percentage of sorghum flour acceptable, in analogy with the action of peroxidase in wheat bread (Hilhorst et al., 1999). These criteria may give directions for selecting sorghum varieties of the present study for bread making.

The purified and characterized peroxidase from sorghum (Dicko et al., 2006b) may be applied in food biotechnology for the modification of carbohydrate-containing hydroxycinnamates (Regalado et al., 2004). Furthermore, the enzyme displayed indole-3-acetic acid oxidase activity. These reactions are useful for (bio)chemical, clinical and biotechnological applications such as bio-depollution of industrial effluents (Adam et al., 1999).

The (bio)chemical characteristics screened are suggested to serve as determinants for sorghum utilization for various foods. It is important to stress that the suitability of sorghum varieties for food and beverages is also dependent on the chemical and physical properties of kernels and process conditions.

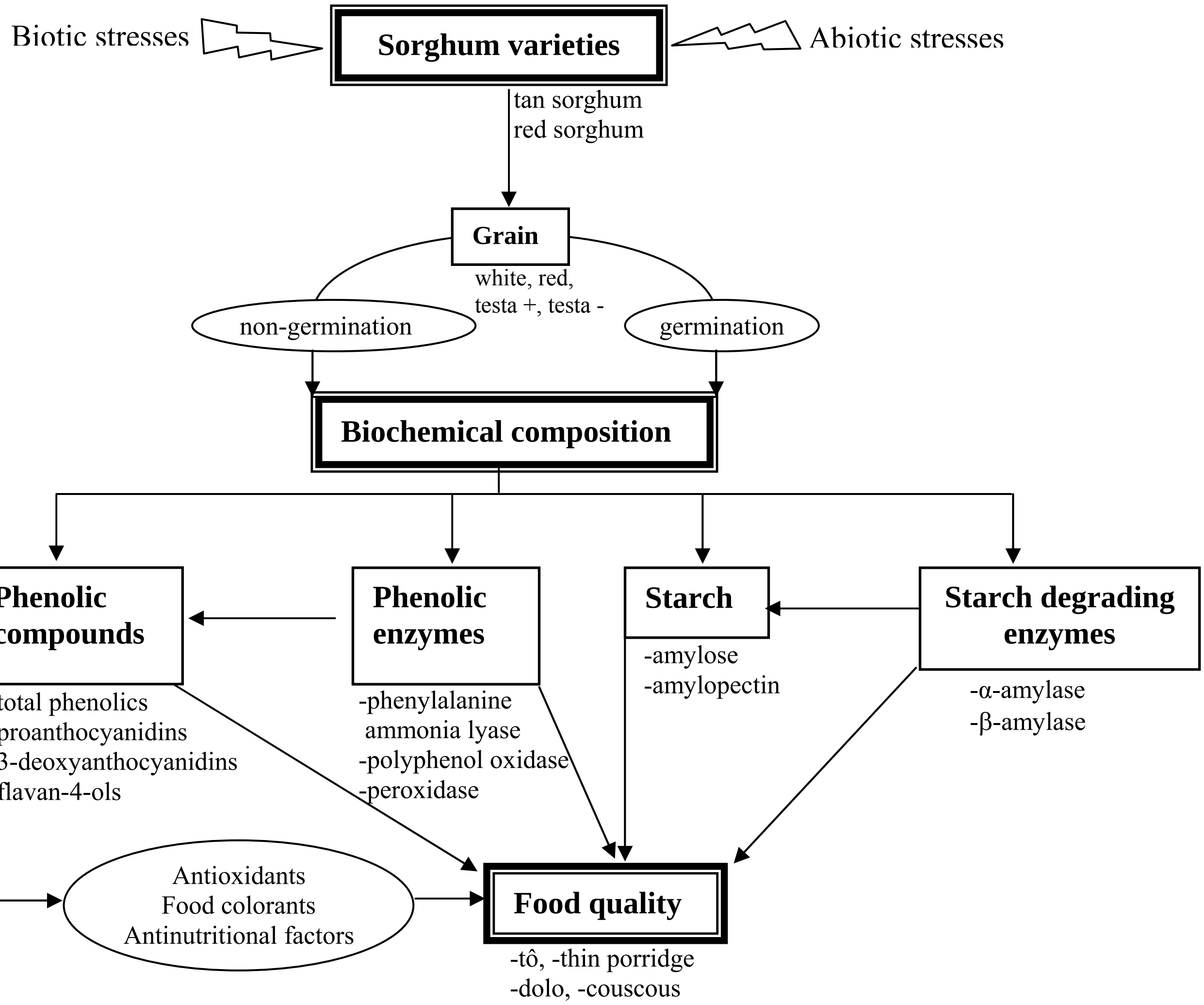

Figure 1. Relationships between biochemical markers relevant for food quality

Biotic and abiotic stresses

The (bio)chemical markers of sorghum studied are not only important for food quality but are also determinants for the grain and even the whole plant resistance to several biotic and abiotic stresses (Dicko et al., 2005b). It is found that contents of phenolic compounds and activities of related enzymes before and after sorghum grain germination are significantly different between varieties resistant and susceptible to biotic (sooty stripe, sorghum midge, leaf anthracnose, striga, and grain molds) and abiotic (logging, drought resistance and photo-period sensitivity) stresses. These results show that contents of phenolic compounds and activities of phenolic enzymes are candidate markers for resistance and susceptibility of grain or plant to stress (Dicko et al., 2005b).

CONCLUSION

Sorghum is a tropical cereal with the high environment tolerance and great possible (bio)chemical diversity. The findings in this work show that it is possible to use state-of-the-art (bio)chemical knowledge to give directions for selecting the most suitable sorghum varieties for specific food utilization. Research on endogenous bioactive components is essential to increase sorghum capacity as the cornerstone of food security in Africa as well as in many developing countries.

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