Correlations Among Bioactive Compounds in Sorghum Grains and Their Impact on Agronomic and Food Qualities

F. Abdoul-Latif[1], H. O. Koné[1], R. G. Bayili[1], M. Diao[1], and Mamoudou H. Dicko[1]

[1]Laboratoire BAEBIB, UFR-SVT, Université de Ouagadougou, Ouagadougou, Burkina Faso.

Summary

The aim of this work is to screen for biochemical markers, which can serve as determinants for sorghum grain quality for food processing. Biochemical compounds such as phenolics 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. Red sorghum varieties as well as the traditional local beer “dolo” display higher antioxidant activities than white sorghum varieties, and these antioxidant activities are comparable to the most important sources of natural antioxidants such as blackberries. This study also revealed that sorghum is also a novel source of peroxidase, which can be used for (bio)chemical, clinical and biocatalytic industries and also for the protection of environment by biodepollution of industrial effluents.

Introduction

The availability of several thousands of sorghum germplasms makes a challenge to screen for biochemical markers in sorghums, which can serve as determinants for sorghum qualities for food and breeding. Phenolic compounds and enzymes involved in their biosynthesis and their oxidation are determinant for sorghum quality for human nutrition [1, 2]. In the other hand, starch and its hydrolytic enzymes are the key issues for sorghum processing. Since phenolic compounds are considered as desirable components of human food, because of their antioxidant activity. These compounds were investigate among 50 varieties and also in sorghum food products such as the local beers “dolo” produced in the capital city of Ouagadougou.

Figure 1. Sorghum bicolor (L.) Moench

Experimental

Fifty sorghum (S. bicolor (L.) Moench) varieties were grown in the same conditions at the experimental station of Saria in Burkina Faso (West Africa). The environment was semi-arid (temperature 30–42 ◦C, annual precipitation 850 mm).Mature grains (≥60 days after anthesis) were harvested, dried and analyazed. Information on the traditional utilisation of varieties was collected from sorghum breeders. The biochemical analysis involved the determination of levels of phenolic compounds, antioxidant activities, starch, lipids, proteins, ash, and determination of the activities of food related enzymes such as amylases, phenylalanine ammonia lyase, polyphenol oxidase, and peroxidases. The major sorghum peroxidase was purified and characterized as previously described [3].

Results and Discussion

As shown in Figure 2, the relationships between the screened biochemical markers give directions for the selection of sorghum varieties for specific local African foods. Levels of starch components (amylose and amylopectin) and amylases were determinant for sorghum use for tô (stick porridge), couscous, weaning foods and alcohol beverages (local beer "dolo" and lager beer) [4]. In addition, for infant porridges, low tannins (proanthocyanidins) containing varieties with low oxidase activities are desired to avoid enzyme-mediated oxidation of endogenous phenolic compounds. Some sorghum varieties [1, 2, 5] (figure 1) as well as "dolo" (local beer) produced in Ouagadougou [6] display high antioxidant activities that are comparable to those of fruits and vegetables [7]. The 3-deoxyanthocyanidins (3-DAs), namely apigeninidins and leucoluteolinidins, are particularly abundant in sorghum grain, but rare or absent in other plants [1]. 3-DAs are of interest because they are more stable in organic solvents as well as in acidic solutions than anthocyanidins commonly found in fruits, vegetables and other cereals [1, 8]. This has been suggested as a potential advantage of sorghum as a viable commercial source of anthocyanins [1]. Furthermore, it is recently shown that sorghum 3-DAs can be industrially extracted and used for tanning skin and hair [9-11]. This industrial use of sorghum 3-DAs is a subject of several application patents [9-11]. Sorghum varieties contain high levels of flavan-4-ols [2]. An agronomic interest exists in sorghum grains containing flavan-4-ols, such as leucoapigeninidin (apiforol) and leucoluteolinidin (luteoforol), because they confer a high resistance of the grain to molding. A new interest in flavan-4-ols is linked to their anticarcinogenic activity [12].

Nowadays, phenolic compounds are generally regarded as desirable components of human food, because of their antioxidant activity. Therefore, they are considered to be of nutraceutical importance [1]. Even for proanthocyanidins (condensed tannins), their earlier classification as essentially antinutritional factors, throughout formation of complexes with proteins and carbohydrates, could be balanced against their potential to serve as biological antioxidants [1]. All phenolic compounds are able to scavenge free radicals through electron-donating properties, generating a relatively stable phenoxyl radical or non radical species. Some phenolic compounds protect against neurological disorders and exert anticarcinogenic, antimutagenic and cardioprotective effects linked to their free radical scavenging activities. Research on discovering naturally occurring antioxidants for use in foods or medicinal materials to replace synthetic antioxidants has attracted much attention. Recently, Awika and co-workers [1] reported methods to determine antioxidant activities of sorghums, their brans, baked and extruded products. For red sorghum the bran had 3-5 times more antioxidant activity than the whole grain [1]. These antioxidant activities were higher than those of blueberries (*Vaccinium* species), one of the most important natural sources of antioxidants. Studying on fifty sorghum varieties, we showed that the varieties are highly diverse in their contents in phenolic compounds and oxidative enzymes. The major sorghum grain peroxidase isoenzyme representing more than 80% of total peroxidase activity was characterized at the molecular level [3]. The enzyme, localized in chromosome 1 of sorghum, is a monomeric glycoprotein containing a non-covalently bound type-b heme. The catalytic properties and primary structure of the enzyme are similar to cereal peroxidases, in particular to barley peroxidase 1. This sorghum enzyme can be applied in food biotechnology for the modification of carbohydrate-containing the phenolics hydroxycinnamates. It is also useful for (bio)chemical, clinical and biocatalytic applications such as the depollution of industrial effluents [13, 14].

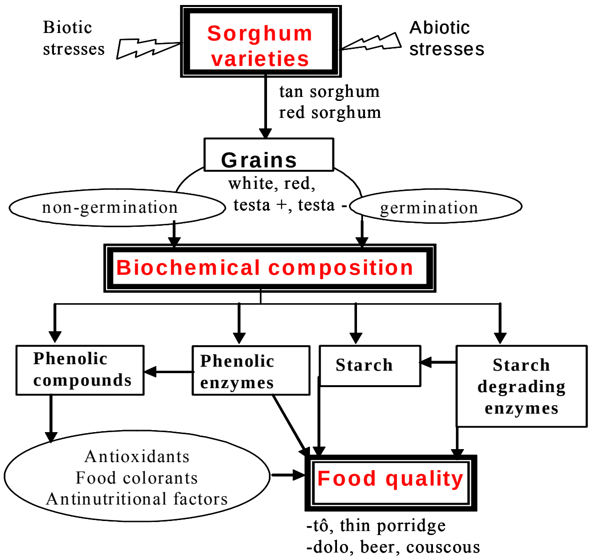

Figure 2. Relationships between biochemical markers relevant for food and agronomic qualities

References

1. Awika, J. M. & Rooney, L. W. (2004). Phytochemistry. 65, 1199.
2. Dicko, M. H. et al. (2005). J. Agric. Food Chem. 53, 2581.
3. Dicko, M. H. et al. (2006). FEBS Journal. 273, 2293.
4. Dicko, M. H. et al. (2006). J. Sci. Food Agric. 86, 953.
5. Dicko, M. H. et al. (2005). J. Chem. Ecol. 11, 2671.
6. Abdoul-Latif F. M. (2007). Msc thesis, Université de Ouagadougou, Burkina Faso.
7. Bayili, G. R. (2007). Msc thesis, Université de Ouagadougou, Burkina Faso.
8. Palé, E. et al. (1997). *Phytochemistry*, *45*, 1091-1093.
9. US Patent N°6511656. Compositions for colouring the skin comprising at least one flavylium salt which is unsubstituted in position 3 and at least one organomodified silicone. 28-01-2003
10. US Patent N°6471949. Compositions comprising at least one UV screening agent and at least one flavylium salt which is unsubstituted in position 3, for coloring the skin, and uses thereof. 29-10-2002.
11. US Patent N°6241785 B1. Use of flavylium type compounds non-substituted in position 3 for dyeing keratinous fibres and compositions containing them. 05-06-2001.
12. Ferreira, D.; Slade, D. (2002). *Nat. Prod. Rep. 19*, 517-541.
13. Adam, W. et al. (1999). In Advances in Biochemical Engineering /Biotechnology. 63, 73-108.
14. Passardi, F.; Penel, C.; Dunand, C. Trends Plant Sci. 2004, 9, 534-539.

Contact Address:

Mamoudou H. Dicko
(mamoudou_dicko2004@yahoo.fr)
Laboratoire BAEBIB
UFR-SVT
Université de Ouagadougou
09 BP. 848 Ouagadougou
Burkina Faso