BIOCHEMICAL AND END-USE QUALITIES OF SORGHUM CULTIVARS FROM BURKINA FASO

H. O. Koné¹², R. G. Bayili¹, F. Abdoul-Latif⁴, M. Diao¹, and Mamoudou H. Dicko¹

¹Laboratoire BAEBIB, UFR-SVT, Université de Ouagadougou, Burkina Faso, ²Université Polytechnique de Bobo-Dioulasso, Bobo Dioulasso, Burkina Faso.

Summary
The aim of the current research is to select the main sorghum cultivars widely produced and processed in Burkina Faso in order to refine their biochemical and end-use qualities, which are determinants for food utilisation. Comparison of levels of starch and its properties, amylase activities, phenolic content, and oxidative enzymes are determined. Physical properties of the kernels such as hardness, grain color (visual and Lab Hunter L, a, b parameters), kernels purity, presence of testa layer, and the germinative energy powers are determined. Comparison of kernels biochemical composition and end-use qualities before and after germination will give direction on nutritional qualities and technological properties of widely available sorghum cultivars from Burkina Faso.

Introduction
Sorghum [Sorghum bicolor (L.) Moench], a tropical cereal, is grown in 99 countries, including Africa, Asia, Oceania, and the Americas [1]. Major producers are the USA, India, Nigeria, China, Mexico, Sudan, Argentina, and Burkina Faso. Sorghum is genetically very diverse. More than 37000 sorghum varieties have been identified. In Africa and Asia the grain is used both for human nutrition and animal feed. The main foods prepared with sorghum are: tortillas (Latino America), thin porridge, e.g. “bouillie” (Africa and Asia), stiff porridge, e.g. tô (West Africa), couscous (Africa), injera (Ethiopia), nasha and kisra (Sudan), dolo (Africa), baked products (USA, Japan, Africa), etc. Sorghum alone is not considered as a bread making cereal because of the lack of gluten, but addition of 20-50% sorghum flour to wheat flour produces excellent bread. Among interesting features of sorghum utilization is biscuits and other cooked products. In the USA and Japan, sorghum utilization as human food is increasing because of its use in snacks and cookies [3]. The future promise of sorghum in the developed world is for wheat substitution for people allergic to gluten. In addition, pasta products, such as spaghetti and macaroni made from semolina or wheat could be made with mixtures of composite flour consisting of 30-50% sorghum in wheat [4]. Pre-cooked sorghum flours mixed with vitamins and exogenous sources of proteins (peanuts or soybeans) are commercially available in many African countries for the preparation of instant soft porridge for infants. Sorghum can be puffed, popped, shredded and flaked to produce ready-to-eat breakfast cereals. Although sorghum has a huge number of food utilisation, all cultivars can not systematically used for the preparation of all foods. Among important biochemical components for sorghum processing are levels of starch.
(amylose and amylopectin) and starch depolymerizing enzymes. Previous research showed that some sorghums are rich sources of micronutrients (minerals and vitamins) and macronutrients (carbohydrates, proteins and fat). Sorghum has a resistant starch, which makes it interesting for obese and diabetic people. Malts of some sorghum cultivars display α-amylase and β-amylase activities comparable to those of barley, making them useful for various agro-industrial foods. Identification of cultivars meeting specific local food of nutritional interest from this great biodiversity is of high importance for human nutrition. Sorghum contains several bioactive phytochemicals, notably phenolic compounds [5-7]. Content of phenolic compounds in sorghum varies both quantitatively and qualitatively among cultivars. Levels of phenolic compounds in some red sorghum reach up to 6% (w/w) [5, 6]. Almost all classes of phenolic compounds including simple phenols, hydroxybenzoic acids, hydroxycinnamic acids, flavonoids (flavanols, flavones, flavanones, isoflavones and anthocyanins), chalcones, aurones (hispidol), hydroxycoumarins, lignans, hydroxystilbenes and polyflavans (proanthocyanidins and prodeoxyanthocyanidins) are found in sorghum grains [7]. Interestingly, there are several data in the literature showing that consumption of some plant-derived foodstuffs with high phenolic content is associated with the prevention of some diseases and that these compounds great variety of pharmacological activities. Some phenolic compounds are anti-inflammatory, anti-human immunodeficiency viruses, immunomodulators, immunostimulants, antibacteria, antioxidants, anti-parasites, antispasmodics, antimutagenic, antithrombotic, gastroprotective, anti-stroke, anti-osteoarthritis, and also inhibit carcinogenesis and cancer growth.

The present contribution focuses on identifying sorghum cultivars from Burkina Faso, which meet specific food requirements from the great biodiversity of sorghums to insure food security in Burkina Faso and enhance the industrial value of sorghum.

Figure 1. Red (A) and white (B) sorghum grains and their panicles from Burkina Faso

Experimental

To insure genotypical and phonotypical diversity among sorghum (Sorghum bicolor (L.) Moench) cultivars, they were collected from sorghum breeders. Twenty five sorghum cultivars were collected from sorghum breeders throughout the country. The choice of the cultivars was based on their commercial availability, and their specificity on contents in biochemical compounds according to our previous screening on 50 sorghum varieties [6, 7]. The sampling was on the varieties SARIASO 1 to 14, IRAT 9, IRAT 10, IRAT 174, IRAT 202, traditional varieties (farkofsi 781, nafonatogué 775, zugilga, SRN 39, 90L1235, kokologho, G1296) and the world wide distributed variety Framida. The current 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, polyphenol oxidase, and peroxidases. Total starch and amylose contents were determined simultaneously
using an iodine-binding spectrophotometric method, and amylpectin was deduced by difference. Total carbohydrate and soluble sugar contents were determined. Total lipid, protein, moisture and ash contents were determined as described previously [7]. The end-use qualities of sorghum were determined based on the following tests, which have been simplified by Professor John Taylor and Ms Janet Taylor (personal communication), University of Pretoria:

- Detection of tannin sorghum grain by the bleach test
- Classification of Sorghum Grain according to Colour
- Estimation of sorghum grain endosperm texture
- determination of germinative energy of sorghum grain
- determination of total defects in sorghum grain.

Results and Discussion

According to the preliminary investigation, the average activities of amylases and phenolic enzymes and the contents of their substrates in sorghum cultivars varied as a function of food utilisation [7]. Sorghums had different contents of starch, amylose and amylopectin. The mean contents of starch, amylose and amylopectin were 63.0, 13.4 and 49.6% respectively. Germination induced a reduction in starch, amylase and amylopectin levels to 59.5, 11.3 and 48.2% respectively. The average proportions of amylose and amylopectin in sorghum starch before germination were 21.2 and 79.8% respectively, while after germination they changed slightly to 19.0 and 81.0% respectively. The content of starch components found in this study is comparable to that reported for other sorghum varieties. Among the varieties screened, no waxy sorghum was found. This is because almost all sorghum varieties cultivated in Burkina Faso are primarily selected for “tô” preparation, for which a high amylose content is needed. On average, \( \alpha \)-amylase and \( \beta \)-amylase displayed similar activities in ungerminated sorghum grains. The levels of \( \beta \)-amylase activity found in the present study are in agreement with those reported in the literature. Upon germination the \( \alpha \)-amylase activity increased several-fold in all varieties. Although on average the \( \beta \)-amylase activity increased upon germination, it either increased or decreased depending on the cultivar. The increase in \( \beta \)-amylase activity in certain varieties may be explained by the release of ‘bound’ forms of the enzyme, as \textit{de novo} synthesis is not expected. In addition, germination may increase the extraction of the bound form of \( \beta \)-amylase through the hydrolysis of cell wall carbohydrates by cell wall degrading enzymes, which may be activated during germination. The inter-varietal difference factors (ratio of highest to lowest values) for \( \alpha \)-amylase activities among varieties were 56 and 18 before and after germination respectively. The inter-varietal difference factor for \( \beta \)-amylase activities was both before and after germination. The inter-varietal difference factors for the \( \alpha \)-amylase and \( \beta \)-amylase activities of the 50 sorghum varieties studied here were higher than the corresponding values found in a previous study on 16 sorghum varieties. This indicates a high polymorphism of amylase activities among sorghum varieties. Although \( \alpha \)-amylase and \( \beta \)-amylase catalyse starch hydrolysis synergistically, their activities were not correlated \((r = 0.07)\) in either ungerminated or germinated sorghum grains, in agreement with other findings. This supports the hypothesis that \( \alpha \)-amylase and \( \beta \)-amylase may have different physiological functions in germinating cereals other than starch hydrolysis.

The mean values of the contents of total carbohydrates, soluble sugars, proteins,
lipids, ash and moisture before germination were 75.2 ± 4.5, 0.50 ± 0.04, 11.5 ± 0.92, 2 ± 0.2, 2.9 ± 0.2 and 7± 0.4% (w/w fresh matter) respectively. Germination induced on average a reduction in the contents of total sugars, lipids and ash by 12, 44 and 34% respectively. Upon germination, protein contents increased by 10–20%, whereas soluble sugars increased up to six fold [7]. The Hunter colour values $L$ (range 68–79), $a^*$ (range 4–12) and $b^*$ (range 8–14) varied between the flours of the selected varieties. Germination changed the colour of the flours ($L$ increased, $a^*$ and $b^*$ decreased), which became lighter. This colour change is attributed to the decrease in 3-deoxyanthocyanidins (apigeninidins and luteolinidins) after germination. The potential energetic value of ungerminated sorghum flour was about 374 ± 22 kcal per 100 g. The average loss of potential energetic value after germination was 13% among the varieties analysed. Before germination the viscosity of all porridges was relatively high (128–202 Pas). Upon germination the viscosities dropped to an acceptable range (1–3 Pa s) for infant porridge preparation. Amylose is more susceptible to retrogradation than amylopectin, and waxy sorghum is less viscous than normal sorghum. Low amylose sorghum varieties are also preferred for extrusion cooking because they give better functional characteristics of the extrudates, such as enzyme susceptibility and solubility. Cultivars with low amylase content, high $\alpha$-amylase activity and which do not contain proanthocyanidins may be recommended for infant porridge preparation. Investigation on kernel physico-chemical properties are still been gathered to identify the most interesting sorghum cultivars to be used in the manufacture of specific local foods. Sorghum phenolic compounds will be qualitatively and quantitatively screened in those cultivars by both analytical and preparative HPLC.

Oligomeric proanthocyanidins will be purified by RP-HPLC and characterized by thiolysis-HPLC. Local foods, i.e. porridges (soft and thick), couscous, and non-alcoholic beverages will be prepared according to current local practices. Changes of the levels and structures (hydrolysis, condensation, or oxidation) of phenolic compounds during sorghum processing will be assessed through HPLC analysis.

References


Contact Address:

Oumou Koné (habykone@yahoo.fr)
Laboratoire BAEBIB, UFR-SVT, Université de Ouagadougou, 09 BP. 848 Ouagadougou, Burkina Faso