The Contribution of Indigenous Small Grains to Food Security, Nutrition, and Health in South Africa

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Cereals are consumed by some 99% of the population in southern Africa, and the most commonly eaten, in order of quantity, are maize, wheat, rice, sorghum, millets, oats, rye, and barley. Cereal grains indigenous to South Africa, commonly referred to as “small grains,” include sorghum (Sorghum bicolor) and millets, predominantly pearl millet (Pennisetum glaucum) and finger millet (Eleusine coracana). The consumption of small grains by the general population declined with the introduction of maize to the African continent, and this has led to reduced agricultural production. Small grains are gluten-free cereals that contain phenolic phytochemicals with potential health-promoting properties. Future cereal grain research in South Africa should be focused on improving cultivation and utilization of indigenous small grain cereals, particularly millets, to take advantage of their largely untapped potential as drought- and climate change-tolerant crops, as well as their potential to contribute to the health and well-being of consumers.

Significance of Cereal Grains in South Africa

The land under cereal production in South Africa in 2013 was ≈13.98 million ha, and of that, commercially produced maize covered an estimated 2.78 million ha and had an estimated yield of 11.72 million tons (2). Indigenous small grains are largely produced by smallholder farmers, except for sorghum, which is produced by commercial farmers as well. Commercial sorghum farms are located mostly in the Free State Province and produce an average 300,000 tons on 150,000 ha of land per year. Smallholder sorghum farms are located mainly in the Mpumalanga, North West, Northern Cape, Eastern Cape, and KwaZulu-Natal Provinces. There are no records on the amount of land under millet production nor on quantities produced. However, from the available information, it is clear that indigenous small grains are not of major commercial importance in South Africa compared with maize, and their food use has declined (2).

Despite their decline in use, indigenous small grain cereals remain important crops for food security, nutrition, and health because they are well adapted to African climatic conditions, and they are becoming increasingly important as “climate change” crops because of their hardness and as cereals with potential for use in production of foods with health benefits.

Sorghum. The origins of sorghum can be traced to Ethiopia, in Africa, and evidence indicates it was domesticated 3,000–5,000 years ago. Today, it is grown in other semiarid parts of the world, including India and the United States (6). The major sorghum growing areas in Africa include the West African countries of Sudan, Ethiopia, and Somalia and most of the Southern African countries, including South Africa. Sorghum grains are classified in several different ways, including as white and brown sorghums and as tannin (bird-resistant) and non-tannin sorghums. Sorghum is a common food source and is consumed in several food forms, such as fermented and nonfermented porridges, gruels, and beverages.

Pearl Millet. Pearl millet originated in central tropical Africa. It was domesticated more than 5,000 years ago and introduced into India 3,000 years ago. It was first cultivated in the United States in 1873 (6). The largest producers of pearl millet are India, Nigeria, Niger, Chad, Mali, Tanzania, Ethiopia, and China. In South Africa, pearl millet is produced at a subsistence level by smallholder farmers and is consumed as a staple food largely in the form of thick porridge, which is prepared from ground grain, and as a beverage. The pearl millet grain has an average weight of 8 mg, and the color ranges from nearly white to yellow, brown, grey, slate blue, and purple. Pearl millet is used as a whole grain (like rice) or is cracked, ground into flour, mixed into dough, and fermented to produce bread or is prepared as a thick porridge. Pearl millet, like most cereal grains, contains a high percentage of starch (70%). Its protein content ranges from 9 to 20% for high-protein varieties; however, a protein content of 11% is considered more
acceptable (7). High-protein genotypes of pearl millet have resulted from breeding programs conducted in India. To date, there are no known varieties that have been developed in South Africa.

**Finger Millet.** Finger millet is the most important millet crop grown in Africa after pearl millet and was domesticated in Africa some 3,000 years ago (6). Finger millet is grown in Central and Southern Africa, and this region produces 55–60% of the African crop. The color of finger millet grain ranges from white to orange-red, deep brown, purple, and nearly black. Finger millet contains high levels of calcium (350 mg/100 g) and iron (12–17 mg/100 g) (7). Traditionally, finger millet has been considered a nutritious food that is beneficial for lactating mothers. The use of finger millet in baby foods is limited due to its low digestibility, which can be improved by fermentation. The malted grain is used for brewing. In brewing, the enzymes that break down starch into fermentable sugars have been observed to be more active than those in sorghum (15).

**Cereal Grain Products Available on the South African Market**

In South Africa, the major cereal grains are available to consumers as commercial processed products that range from milled flour to breakfast cereals and snacks. Maize is a popular cereal found in various forms in the South African market, including maize meal for preparation of porridges and beverages, breakfast cereals such as corn (maize) flakes, instant porridges, and extruded snacks. One of the leading cereal grain processors in South Africa, Bokomo, has several products on the market made from maize and wheat—a range of products that includes corn flakes, cereal bars, muesli, and porridges. Kellogg's corn flakes are also prominent in the South African market. Other cereal products are extruded snacks. One of the leading cereal products that includes corn flakes, cereal made from maize and wheat—a range of grain processors in South Africa, Bokomo extruded snacks. One of the leading cereal corn (maize) flakes, instant porridges, and products to these millets are imported in addition to sorghum, the most similar small grain, and several South African food companies, such as Tiger Brands and Foodcorp, produce milled sorghum flour for making porridges. In addition, a pre-cooked, fortified, milled sorghum product, Morvite, is made by Tiger Brands. There are almost no processed pearl or finger millet products in the mainstream South African market. A quick visit to health shops such as Dis-Chem Pharmacies (a huge South African group) and supermarkets with health food sections reveals that, in addition to sorghum, the most similar products to these millets are imported small grain cereals such as quinoa, amaranth, and some undefined millet products. Packaged sorghum grain and millet flour products store are shown in Figure 1.

The absence of pearl and finger millets on the market despite research demonstrating the potential for utilizing these grains in baked products (e.g., breads and cookies) is notable (17). Future cereal science research in South Africa should focus on increasing and improving utilization of indigenous small grains (sorghum and millets) in the mainstream market through development of products that would increase production and consumption.

**Table 1. Summary of reported levels of mineral micronutrients (mg/100 g) and total phenols in sorghum, pearl millet, and finger millet compared with maize and wheat**

<table>
<thead>
<tr>
<th>Grain</th>
<th>Iron</th>
<th>Zinc</th>
<th>Calcium</th>
<th>% Total Phenols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum</td>
<td>3.7–4.3</td>
<td>0.3–1.6</td>
<td>27</td>
<td>0.3</td>
</tr>
<tr>
<td>White</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brown, tannin</td>
<td></td>
<td>2.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearl millet</td>
<td>3.0–20</td>
<td>2.2–6.6</td>
<td>25</td>
<td>0.1</td>
</tr>
<tr>
<td>Finger millet (brown)</td>
<td>5.0–17.0</td>
<td>No value</td>
<td>330–350</td>
<td>0.34–1.84</td>
</tr>
<tr>
<td>White maize</td>
<td>1.1–2.7</td>
<td>1.9</td>
<td>26</td>
<td>0.2</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.4–3.5</td>
<td>0.8–3.1</td>
<td>30</td>
<td>0.06</td>
</tr>
</tbody>
</table>

* Data sources: Devi et al. (3), Dlamini et al. (4), Klopfenstein and Hoseney (7), Lestienne et al. (8), Nambar et al. (10), Ragaee et al. (12), and Siwela et al. (14).
tryptophan. Unfortunately, small grains have not been researched as extensively as maize and other cereal grains regarding nutrient biofortification and crop improvement. However, some efforts have been made to produce nutrient-enhanced sorghum using induced mutation and recombinant technologies, and to date, the South African government has approved growth trials in greenhouses at the Council for Scientific and Industrial Research (CSIR). Technologies such as induced mutations are more widely accepted, and research has produced improved varieties of sorghum at a laboratory scale. Mehlo et al. (9) recently published a report on improved sorghum mutants produced by induced mutation that showed accumulation of unusually high levels of lysine and other essential amino acids in the endosperm.

The use of sorghum grain as a food also has raised concerns regarding the less digestible starch found in sorghum compared with maize. Although the digestibility of sorghum starch appeared to be problematic, recent research has demonstrated that foods that have less digestible (i.e., more resistant) starch may play a role in alleviating some metabolic syndromes, such as type 2 diabetes (3), for which consumption of low glycemic foods is beneficial in terms of controlling blood glucose levels after consumption of food. The starches in low glycemic foods are digested slowly, and thus, there is a slow release of glucose into the blood stream, which avoids the detrimental health effects of accumulation of glucose in the blood. Research using finger millet has shown favorable blood glucose profiles in rats with induced diabetes, as well as in people who have non–insulin-dependent diabetes (3).

Several methods have been proposed to improve nutrient intake using some small grains cereals indigenous to Africa. The
most promising approaches involve increasing the natural levels of specific nutrients in the cereal grain using a biofortification process. Biofortification can be accomplished through conventional breeding and use of recombinant DNA technology to introduce genes that will increase, for example, provitamin A content. Some of the advantages of biofortification may be improved stability of vitamins because they are part of the plant tissue structure, through which they may be protected from processes such as heat degradation and oxidation. Studies on breeding maize varieties with high levels of provitamin A carotenoids are underway at the University of KwaZulu-Natal, and several papers have been published on the food and potential health properties of these maize varieties (1,11). Taylor et al. (16) recently reported improved zinc and iron absorption when 2-year-old children were fed iron- and zinc-biofortified pearl millet.

There is also growing interest in sorghum and millets for their phytochemical contents, which research has shown may have health benefits, including reduction of oxidative stress; anticancer, anti-inflammatory, and antihypertensive effects; and cardiovascular disease prevention (5,16). Some varieties of sorghum, namely the red and brown varieties, as well as brown finger millets, contain high levels of polyphenols that contribute to high antioxidant activity (4,5,14). The total phenolic contents of these grains are summarized in Table 1. Food product development studies have been conducted to facilitate the utilization of sorghum and millets in the commercial production of nutritious and health-promoting food products (16), but more research is needed.

Future Market Potential and Utilization of Indigenous Cereals

Sorghum and millets can be targeted for gluten-free cereal foods such as bakery products, pastas, and other commercial products in which cereals are needed for their high carbohydrate content (17). Their slowly digested starches also make sorghum and millets suitable for use in foods that can help diabetics avoid spikes in blood glucose after eating.

Interestingly, smaller amounts of pearl millet and sorghum are needed to cook a traditional main meal of thick porridge than is the case for maize, and pearl millet porridge provides satiety for a longer period of time, as well as more energy. Meals containing pearl millet are particularly well suited for people performing heavy manual labor, like farmers. It has also been verified that pearl millet and sorghum grains can be stored for longer periods of time than maize: 3–5 years for pearl millet and sorghum compared with 8 months for maize. Some of the reasons given for the better storage properties of sorghum and millets are the presence of phenolic compounds that exhibit antifungal and antimicrobial properties.

**Conclusions**

Cereal-based products are the most commonly consumed food products globally due to their relative affordability and chemical composition, and they contribute significantly to the food security, nutrition, and health of human populations worldwide. Their contribution is particularly significant for the predominantly low-income populations of countries in Sub-Saharan Africa, including South Africa. In South Africa, the challenge has been to improve nutrient intake using fortified cereals as mandated by the South African government food fortification program.

The indigenous small grains sorghum and millets, which are better adapted to the generally harsh agroclimatic conditions encountered in the Sub-Saharan African region, including South Africa, have the potential to contribute more to the food security, nutrition, and well-being of the general population—unfortunately they currently are grossly underutilized. Therefore, future research should focus on facilitating the increased production and food utilization of sorghum and millets. Among other factors, genetic manipulation and food product development complemented by a supportive and promotional policy environment will be important in achieving this goal.

**References**