Should the Bambara groundnut remain underutilised?

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The Bambara groundnut (BGN) (Vigna subterranea) is an African indigenous legume high in protein, low in fat and high in phenolics with antioxidant properties. Yet it is classified as underutilised and is unknown to consumers and national and international food baskets. Our chains of value-added products from this legume, such as beverages and fibres, indicates that BGN has the ability to break the cycle of poverty and malnutrition in Africa.

In Africa
Consumers are demanding new food products that have health benefits, coupled with the apparently increasing need for convenience food on the continent. Underutilised food crops prevalent on the continent are loaded with healthy nutritional components (Jideani & Murevanhema 2013; Jideani & Diedericks 2013). One such crop is BGN. BGN is an indigenous African crop that is grown as food across the continent (Atiku et al. 2004) as well as in Indonesia, Malaysia and Sri Lanka (Elayeb et al. 2011). BGN is a popular crop because of its resistance to drought and pests and its ability to produce a reasonable crop when grown on poor soils. It has long storage life (Amartefio & Moholo 1998), a much desired property in the face of global warming.

Whole BGNs are the edible seed of the BGN plant, a legume of the family Fabaceae. They are a low-fat source of protein. The plant is highly nutritious and its seed contains about 49–63.5% carbohydrate, 15–25% protein, 4.5–7.4% fat, 5.2–6.4% fibre, 3.2–4.4% ash and 2% mineral (Amartefio & Moholo 1998). BGN is a good source of fibre, calcium, iron and potassium and unusually high in methionine, an essential sulphur-containing amino acid. The essential amino acid of BGN is comparable to that of soybeans in lysine, methionine and cysteine (Omoikhioho 2008). Due to BGN’s rich nutritional profile, it has been referred to as “a native solution to Africa’s Food Crisis” (Stone et al. 2011). There are seven BGN varieties in terms of colour, namely black, red, cream/black-eye, cream/brown-eye, cream/no-eye, speckled/flecked/spotted and brown (Figure 1) (DPP 2011). Usually, the seeds are mixed when purchased. In our studies we separated them into four varieties based on the seed and eye colour: black-eye, brown-eye, red and brown (Figure 1).

Figure 1: Bambara groundnut varieties
Our objective is to describe our efforts in harnessing the rich nutritional profile of BGN into value-added products that will effectively contribute to food security in South Africa and Africa at large.

**Indigenous knowledge**

Indigenous knowledge (IK) is the local knowledge unique to a given culture or society. Much IK associates BGN with medicinal properties (Figure 2). These include leaf preparations applied to abscesses and infected wounds; sap from leaves applied to the eyes to treat epilepsy; roots sometimes taken as an aphrodisiac; and pounded seeds mixed with water and used to treat cataracts.

Pale et al. (1997) have identified 3-β-D-mono-oligoside of cyanidin, petunidin and malvidin from the pigmented seed coat of BGN seeds. Antioxidants from nuts are reported.
to be generally localised in the seed coat, with lower amounts in the cotyledons. Perhaps the bioactive content of BGN may explain some medicinal uses of BGN reported in some countries (Goli et al. 2011; NRC 1994, Swanevelder 1998; Pale et al. 1997). Despite BGN’s rich nutritional profile, it has not made it to the national food basket, let alone to the international one. Our objective was to establish the potential of BGN as a source of food and nutrition for food security using network analysis.

Network analysis is a branch of graph theory that aims to describe the quantitative properties of networks’ interconnected entities by means of mathematical tools. Literature information on the uses of BGN were obtained and described as a set of interconnected objects that was analysed using the NodeXL software package and the Harel-Koren Fast Multiscale algorithm. The BGN network consisted of 33 nodes and 58 edges. The usefulness of BGN was more targeted to functional food and therapeutic uses as determined by high in-degree for functional (10) and therapeutic use (11). The functional and therapeutic uses of BGN were from the BGN seeds and its flour, with out-degree of 11 and 8 respectively. Centrality helps to determine the key players or the most prominent member of a network.

BGN’s seeds, flour, therapeutic value, functional food value and protein content control the value of BGN with 443.8, 257.2, 278.6, 198 and 141.8 betweenness centrality (Figure 2) respectively. Hence, value-added products from BGN seeds and flour will provide functional foods with therapeutic benefits for food security programmes and interventions. Our initial step in this direction was to explore the potential of BGN flour in milk and yoghurt beverages as well as dietary fibres.

**Flour and food security**

**BGN flour as emulsifier/stabiliser in food systems**

Suitability of Bambara groundnut flour (BGNF) as natural emulsifier/stabiliser in food emulsion systems was assessed. Gelatinised BGNF stabilised the oil-in-water emulsion. All the BGNF emulsions were macro emulsions, which are desirable in some food applications. All emulsions were stable to emulsion breakdown due to creaming. BGNF stabilised emulsions were characterised as highly spreadable (pseudoplasticity), thixotropic which is desirable in mastication and chewing, (meaning good chewability) and highly rigid, necessary for withstanding harsh conditions during development, transportation and storage.
**BGN flour in beverages and dietary fibre**

In addition to its oil, BGN seeds have the highest concentration of soluble fibre compared to other beans; this could contribute to the prevention of colon cancer. Some reported BGN phytochemicals, including anthocyanin and flavonoids, impart many beneficial health effects and reduce the risk of many chronic illnesses (Pale et al. 1997). This appears to support IK. Unfortunately, consumers are unaware of BGN’s rich nutritional benefits and it is not part of the national or international food basket. Furthermore, it is reported that the highest rates of lactose intolerance are found in Africa, South America and Asia, with approximately 50% of the population affected and almost 100% in some Asian countries. Vegetarianism is on the increase either by choice or due to disease. Hence, there is increasing demand from consumers for lactose-free or plant-based products. There is a continued trend towards healthier eating choices. BGN milk and yoghurt will fill this gap as they are plant-based and lactose-free. The objective was to harness the rich nutritional content of BGN into functional food for consumer wellness.

As an initial step to harness the rich nutrition of BGN, we demonstrated that BGN value chains can contribute to national food security. We produced two patents: (1) a process for the production of BGN milk (BGNM) and BGN probiotic yoghurt; and (2) BGN dietary fibre (Jideani & Murevanhema 2013; Jideani & Diedericks 2013). These products were high in polyphenols, an indication of the nutraceutical content, and may therefore contribute to a healthy diet. BGNM supported the growth of probiotics and protected them against in vitro gastric juice and bile. It is expected that the yoghurt will benefit the consumer through maintaining good balance and composition of intestinal flora, helping to increase the body’s ability to resist the invasion of pathogens, thereby maintaining the host’s efficient nutrition.

BGN insoluble fibre (BGNIF) is high in phenolics (6.14–15.56 mg/g GAE) with higher swelling capacity compared to commercial fibres. The major neutral sugars in BGNIF include the co-eluted arabinose/galactose, xylene and mannose, with proportions of these monomers indicative of hemicellulosic polysaccharides. Introduction of BGNIF into white bread resulted in uniform crumb grain with smaller pores, higher total dietary fibre content, reduced gumminess, chewiness and softer crumbs compared with the control white bread (Figure 3). The presence of galactose, xylene and mannose in BGN soluble fibre (BGNFS) (Figure 4) suggests galactomannan properties typical of conventional hydrocolloids such as locust bean gum. All BGN fibres, especially the soluble fibres, possess higher fat absorption capacity than pea fibres. Hence, BGN fibres can be incorporated into high-fat products and emulsions. BGNFS was effective in stabilising an orange beverage emulsion, so it could be a new ingredient for the beverage industry.

**Figure 3:**
Bambara groundnut insoluble fibres and bread baked with the fibres

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Conclusion
We have demonstrated that BGN has the potential to contribute to food security through its diversity of products. This cannot be a reality until these products are commercialised. We are therefore looking for manufacturers willing to partner with us in the venture. The commercialisation will open up markets for BGN and its products and will consequently elevate its status from underutilised to a grain of choice in the food industries both in Africa and abroad.

Figure 4:
Bambara groundnut soluble dietary fibres

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References

*Due to space constraints, a full list of references could not be accommodated. It is available on request.

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