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ANALYSIS OF SMALL-SCALE FARMERS' INDIGENOUS KNOWLEDGE OF BAMBARA GROUNDNUT - A CASE OF SYRINGAVALE, ZIMBABWE

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ABSTRACT

Bambara groundnut (BGN), a legume in the Fabaceae family, is typically cultivated on a small scale by female subsistence farmers in sub-Saharan Africa. Despite being the largest exporter of BGN in southern Africa, Zimbabwe considers BGN a supplementary crop. Although components of BGN have been previously studied, this study involved active participation from local farmers, leading to a more community-driven understanding of perceptions and practices surrounding this legume. This study was conducted in the Syringavale community in Marula, situated in the Matabeleland South province of Zimbabwe and consisted of fifty Black African respondents [females (86%) and males (14%)]. The primary aim was to collect indigenous information on consumer perceptions, agricultural and processing practices, cultural beliefs and superstitions, and the overall significance of BGN in the community. Simple random sampling was used to select fifty households, from a list of sixty BGN-cultivating households, in the study area, followed by judgmental sampling to choose one respondent per selected household. Then after, a mixed-methods approach was applied, with structured questionnaire administered first, followed by in-depth interviews. Thematic analysis was employed to systematically identify and categorise themes, sub-themes and patterns within qualitative responses. Bambara groundnut was cultivated at household level, mostly by married women over the age of 40 and held dietary, agricultural, medicinal and traditional significance. Different components of the BGN crop, such as the seeds, leaves, flowers, roots and pods were reported to serve as food, fodder, medicine, maturity indicators and compost. Boiling, soaking, roasting, baking, cracking and frying were the cooking methods used in the community, with boiling being the most common method used by 100% of respondents. Respondents (100%) showed a preference for the mature green seed over the dry seed due to the significant time and energy consumption associated with cooking the latter. Some respondents (52%) sold their BGN produce in the open market, at home, to wholesalers, as well as in petty batter. Urbanisation, heavy rains and cultural beliefs were cited as major hindrances to BGN production. The prioritisation of BGN in terms of land allocation was recommended considering its nutritional and economic value as well as its potential contribution to the alleviation of poverty and malnutrition.

Key words: Bambara groundnut, subsistence farming, legumes, poverty alleviation, small scale farmers

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INTRODUCTION

Bambara groundnut (BGN) [*Vigna subterranea* (L.) Verdc] is a highly inbred, self-pollinating annual legume belonging to the Fabaceae family, commonly cultivated on a small scale by low-income female subsistence farmers in sub-Saharan Africa [1, 2, 3, 4]. Bambara groundnut is positioned third among legumes in Africa in terms of production, socioeconomic impact, and consumption, trailing groundnut (*Arachis hypogaea*) and cowpea (*Vigna unguiculata*) [1, 5]. This legume is nutritionally rich, with carbohydrates (55-70%), fat (6-9%), protein (17-25%), dietary fibre (5-6%), an appreciable amount of vitamins (carotene, riboflavin, niacin and thiamine) and minerals [potassium (1545-2200 mg/100 g), magnesium (32-335 mg/100 g), calcium (30-128 mg/100 g), iron (2-9 mg/100 g) and phosphorus (81-563 mg/100 g)] [6, 7, 8]. Bambara groundnut has a significant position in most rural communities, serving as a vital protein source, particularly for impoverished households who cannot afford meat-based protein alternatives [4]. It is rich in the essential amino acids isoleucine, leucine, lysine, methionine, phenylalanine, threonine and valine [9] making it suitable for complementing cereals such as; millet, maize and sorghum, which have lysine as a limiting amino acid and commonly grown in rural areas in Zimbabwe. Furthermore, unlike groundnuts and cereals grown in many rural regions of Zimbabwe, BGN possesses the capacity to fix 32-81 kg of nitrogen per ha. This is attributed to its symbiotic relationship with the nitrogen fixing rhizopus resident in its root nodules, thereby contributing immensely to soil fertility and crop rotation, minimising the need for artificial fertilisers [1, 8, 10]. Bambara groundnut yields well in nutrient-deficient soils and is largely drought, disease and pest resistant, making it an excellent crop for local farmers, in arid and semi-arid regions, that do not afford expensive irrigation systems and fertilisers [3, 11, 12, 13]. Bambara groundnut also serves as a cover crop, thereby reducing soil erosion [1].

Climate change has led to reduced and erratic rainfall across the world resulting in decreased crop yield, hence the need to pay attention to more resilient crops. Furthermore, to develop a more nutritionally sustainable future in agriculture, there is a requirement for high quality and nutritionally rich underutilised and orphan crops such as BGN [11]. As a crop, BGN currently lacks proper cultivation systems and agronomic practices to significantly increase its yield [14]. Empirical evidence and the results of various studies have revealed that BGN has considerable potential both as a crop and as a food product, yet it still has not received as much research and attention as it deserves [1, 6, 15].

The BGN crop is geocarpic and when mature it can be consumed as fresh or dried and stored for consumption later in the year [16]. Fresh seeds are preferred to dry seeds by a majority of consumers mainly because they do not require large

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amounts of time, water and energy to cook [3, 16]. The dry seeds are commonly soaked prior to cooking, either for standalone consumption or incorporation into diverse dishes such as soups, gravies, and relishes [1]. Some of the common processing methods of BGN include boiling, roasting, baking, cracking, frying, dehulling, fermentation and canning [2, 17, 18]. While BGN is primarily cultivated for human consumption, it also finds application in non-food contexts such as medicinal uses, fodder, compost and plays a role in traditional ceremonies like funerals, weddings, rituals and gift exchanges [1].

Bambara groundnut is not a major crop in Zimbabwe; it is only grown as a supplementary crop. Despite its minor role in domestic cultivation, Zimbabwe remains the biggest exporter of BGN in southern Africa, contributing about 2000-3000 tons per year to southern African countries [3, 8]. The yield of BGN has been steadily decreasing over the years with current yield in Zimbabwe estimated at 0.205 t/ha over a harvesting area of 83, 750 ha [19]. This can be attributed to several factors such as farmers giving priority to more prominent food crops such as maize, sorghum, millet and peanuts. Bambara groundnut plays a huge role in the nutritional and socioeconomic lives of women and is known as a 'woman's crop' as its largely cultivated by women. This can be attributed to the fact that rural areas in Zimbabwe are predominantly populated by women and children given that many men migrate for employment. Furthermore, taboos and superstitions as well as lack of markets also contribute to hindrances preventing men from actively engaging in BGN production [3].

This study focused on Syringavale, a small community in Marula, Zimbabwe. Increased cultivation of BGN in the Syringavale community would play a crucial role in mitigating the over utilisation of common legumes such as groundnuts, reducing the over cultivation of crops such as millet, sorghum and maize as well as serve as an important source of protein for the low-income households. The acceptance of a crop as a food source by consumers is largely dependent on the overall knowledge of the crop [14]. Although BGN has been extensively studied, this study involves active participation from local farmers leading to a more community-driven understanding of perceptions and practices surrounding BGN that reveal valuable insights not captured in previous scientific or agronomic studies. Furthermore, the focus on subsistence farmers in a community distinguishes this study from those on commercial farming and offer unique insights different from studies conducted in other regions. While previous studies have delved into certain aspects of BGN, such as its nutritional content and agronomic aspects, this study provides a holistic exploration, including uses, consumption patterns, preparation methods, threats, medicinal properties, as well as superstitions and taboos associated with this legume. This comprehensive

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approach contributes to a more nuanced understanding of the crop's role in rural communities and provides insight into why BGN remains a lesser crop farmed at household level. Findings from this study will contribute practical knowledge and intervention strategies aimed at promoting sustainable BGN farming practices as well as ideas on how to increase the utilisation of this underutilised legume.

Bambara groundnut (BGN) has the potential to significantly contribute to food security and alleviate malnutrition, particularly in rural communities [2, 10]. It stands out as a low-budget, cost-effective and reliable crop that thrives in adverse conditions deemed unsuitable for other crops [20]. Education about the nutritional value and diverse uses of BGN is essential, especially for the public, particularly those in lower-income groups susceptible to malnutrition due to limited dietary variety.

The objective of this study was to collect indigenous information on consumer perceptions, agricultural and processing practices, cultural beliefs and the overall significance of BGN in Syringavale community. It was hypothesised that significant gender-based disparities exist in the utilisation, preparation and usage of BGN and that socio-demographic factors have a significant impact on the production and marketing of BGN. Specific research questions guiding the research included: (i) What parts of the BGN plant are useful and what are the uses? (ii) What is the stage of the crop when used for food and what parts are useful for food? (iii) What are the main cooking methods and common dishes made from BGN? (iv) How do you acquire BGN? (v) Do you sell BGN? If yes, where do you sell it? (vi) What are the factors that influence the consumption of BGN? (vii) Is abundance of BGN threatened? If yes, what are the threats? (viii) Are there medical benefits associated with BGN? and (ix) Are there associated taboos, stories and/or superstitions associated with BGN?

MATERIALS AND METHODS

Study area

This study was conducted in Syringavale community in Marula located in Mangwe District in the Matabeleland South province of Zimbabwe. Marula is in the subtropical dry forest biome and has a semi-arid climate receiving an average of 602 mm of rainfall per year. Bambara groundnut requires 500-750 mm of rainfall per annum [10, 21, 22], making Marula community suitable for its cultivation. The major crops cultivated in the community are maize, millet, sorghum and peanuts. The livelihood of the community members was small scale crop and livestock farming, remittances from relatives, food aid from non-governmental organisations and petty trade. The study was approved by the Department of Agricultural

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Extension Services (Agritex), under the Ministry of Lands, Agriculture, Fisheries and Rural Development in Zimbabwe.

Sampling process

The study consisted of fifty Black African respondents [females (86%) and males (14%)] living in a rural community. The effect of gender, marital status, age, economic status and level of education on the production and marketing of BGN was evaluated from the data collected. The Agritex officers stationed at Marula supplied a list of sixty households that cultivated BGN and a two-stage sampling design was implemented. In the first stage, fifty households were selected from the list of BGN cultivators through simple random sampling, thus giving every household an equal opportunity to be included in the study. The selection process was entirely based on chance and guaranteed an unbiased, representative and equal probability of inclusion for each household [23]. In the second stage, a single individual, actively involved in the cultivation of BGN, from each selected household was chosen using judgmental sampling [24]. Judgmental sampling is aimed at efficiently utilising limited resources by identifying and selecting individuals or groups with significant knowledge or experience related to the research focus. Prior to meeting respondents, Agritex officers and the village headman were consulted to obtain verbal informed consent, as well as to explain the objectives of research.

Study design and data collection

A mixed-methods approach was employed in this study, combining structured questionnaires with in-depth face-to-face interviews to explore responses, nuances and clarify ambiguities [25]. Mixed-methods is a valuable approach for understanding complex phenomena because it combines both quantitative and qualitative data collection and analysis, allowing for a more complete understanding of a topic [26]. Primary data were obtained by administering fifty copies of questionnaire to respondents followed by a face-to-face in-depth interview. The study was explained to the respondents and their verbal consent was obtained before each interview. The interviews and questionnaire administration had open-ended and close-ended questions. The questionnaire sought information on the uses, consumption pattern, preparation methods, threats, ethnomedical properties, as well as superstitions and taboos associated with BGN. The interviews were conducted in *isiNdebele* and *tjiKalanga*, the local languages. Interviews were carried out by visiting the homes of respondents accompanied by an Agritex officer. Interviews were recorded with the consent of the respondent and notes were taken during the interview. All interviews were translated into English and transcribed. Participant identities were anonymised, ensuring the privacy of individuals. Recordings were securely stored on a

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password-protected laptop, and physical documents, including notebooks, completed questionnaires containing respondents' data and archived data, were securely stored in a locked cabinet, upholding participant confidentiality beyond the conclusion of the study.

Data analysis

Data analysis was performed through descriptive and inferential statistics. Thematic analysis was employed to systematically identify and categorise themes, subthemes and patterns within qualitative responses concerning BGN uses, consumption, preparation methods, threats, and cultural aspects. Thematic analysis is commonly used in mixed-methods research for a thorough understanding of a phenomenon. It involves a series of distinct procedural steps, including familiarisation, coding, theme generation, review, defining and naming, and the final write-up [27]. Table 1 shows the themes of the respondents' perspectives, opinions, knowledge, experiences and profiles.

RESULTS AND DISCUSSION

Demography of Bambara groundnut farmers in Syringavale community

The demographic characteristics of the respondents in this study are presented in Table 2. Female respondents (86%) constituted the largest group among BGN cultivators thus corroborating the assertion that BGN is mostly cultivated by subsistence female farmers throughout Zimbabwe [2, 3] and the rest of Africa [8, 11]. Of the respondents, 62% were married, 20% were widowed, 12% were single and 6% were separated. The age groups were divided into 21-25 years (4%), 26-30 years (10%), 31-35 years (14%), 36-40 years (26%) and >40 years (46%). Age seemed to play a role in BGN production as the majority (72%) of the respondents were over 35 years old (Table 2). Farmers attributed this trend to a significant number of individuals below the age of 35 being away from home in pursuit of education or employment. Only 6% of the respondents identified their economic status as affluent, while the rest indicated a status below average (54%), average (22%) and poor (18%) which is typical of rural communities in Zimbabwe. This finding reinforces the notion that BGN is perceived as a 'poor man's crop' [6]. The majority of respondents (86%) had received formal education in the form of primary (40%), secondary (36%), diploma (10%) and farming courses (4%).

Ethnobotanical properties of the Bambara groundnut plant

Useful parts of the BGN plant

The parts of the BGN plant that were deemed important by the farmers are presented in Figure 1. Of the respondents, 52% said the leaves were highly useful, 40% said they were fairly useful and 8% said they were not useful.

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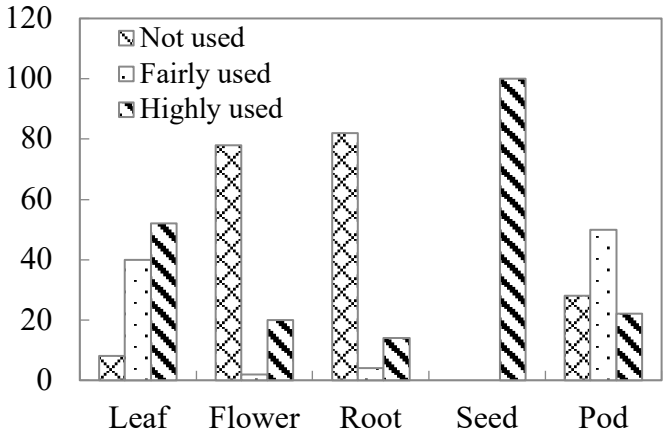

Figure 1: Useful parts of the BGN plant

The majority of the respondents (92%) stated that the leaves of the BGN crop were useful as an indication of harvesting maturity as they turn yellow and start wilting when the BGN crop is ready for harvesting. This was in agreement with literature where it is stated that BGN crops are mature when the leaves turn yellow and the majority of the pods have hard shells [21, 28, 29]. The respondents (4%) with farming certificates indicated that BGN was a good cover crop, preventing soil erosion, as its leaves grew close to the ground.

With regards to pods, 50% of the respondents said they were fairly useful, 28% said they were not useful and 22% said they were highly useful. After harvesting, the leaves and pods were said to be used as compost and the pods as fodder, especially for pigs.

The flower and root were the least useful parts of the plant and were seen as not useful by 78% and 82% respondents, respectively. According to the respondents (22%) who highly and fairly found the flowers of the BGN crop useful, flowers signify the onset of plant yield thus serve as an indicator for the commencement of earthing up. Earthing up was reported to have a positive impact on pod formation and growth, further emphasising its significance in the cultivation of BGN. Earthing up, a common practice among subsistence farmers throughout Africa, involves covering the base of the BGN plant up to the crown, proven to enhance seed yield [29, 30]. Respondents mentioned earthing up approximately one to two months after planting, aligning with recommended practices as it is advised to earth up the BGN crop within the 30-60 day timeframe post-planting [13].

The roots of the BGN plant were said to be highly useful (14%), fairly useful (4%) and not useful (82%). The respondents (18%) who found the roots fairly and highly useful said it was because they bore seeds. Some respondents (4%) highlighted the soil-enriching benefits of BGN, noting that its roots contribute to soil fertility,

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making it important in crop rotation. These respondents had farming certificates and were therefore familiar with the science behind the BGN crop. The respondents referred to the nitrogen-fixing properties of BGN, positioning it as an advantageous rotational crop with major cereal crops. Additionally, BGN was emphasised as a cost-effective crop, as it does not require any fertiliser by 4% of the respondents. Research corroborates this, indicating that BGN fixes a substantial amount of atmospheric nitrogen (32-81 kg per ha^{-1}) through a symbiotic relationship with Rhizobium bacteria [8, 13].

All respondents (100%) said the seed was highly useful as planting seed, food as well as for medicinal applications and ceremonial practices.

Acquisition of Bambara groundnut

In response to the question asking how the respondents acquired BGN, the respondents (100%) stated that BGN does not grow in nature and must be cultivated (Table 3). All the respondents (100%) involved in the study cultivated BGN at household level and the seed, which is the only part of the plant used for human consumption, served as an important part of their diet. All respondents (100%) cultivated mixed landraces and graded seeds based on size and undamaged surfaces as indicators of quality. This was in agreement with previous studies that reported the absence of grading systems in BGN, further illustrating how the crop is marginalised [3, 29].

Despite BGN not being deemed a lucrative cash crop in Syringavale, it is still actively sold within and around the local community. Some respondents (38%) always purchased BGN seeds from the open market or shops, 54% seldom purchased BGN seeds and 8% never purchased BGN seeds. Respondents who seldomly purchased BGN seeds said they only did so during seasons where their own crops failed and they did not have seeds from previous harvests. When asked about their willingness to buy BGN products from supermarket shelves, 4% of respondents expressed reluctance, citing concerns about the chemicals added to supermarket-sold food. In contrast, 96% of respondents indicated they had no objections. All respondents (100%) indicated that they could obtain BGN from their friends, relatives and neighbours at no cost. The advantages of such practices include convenience, community self-sustenance and the preservation of local customs, which adds value to traditional systems. However, the drawback is that these practices can lead to poor germination and reduced yield, especially when using low-quality seeds [3]. In-breeding leads to heightened homozygosity and limited gene flow, thereby reducing genetic diversity in crops [1]. This can lead to linkage drag of detrimental genes, compromising agronomic performance and grain yield [31, 32]. Agritex respondents concurred on the necessity for breeding programs to enhance the quality of BGN seed sources.

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All respondents (100%) reported allocating limited acreage to BGN, reinforcing its characterisation as a subsistence crop. In subsistence farming, crop diversification is a cost-effective way of mitigating drought and other uncertainties experienced in subsistence agriculture [3]. Subsistence farming is the main source of livelihood, contributing to both food security and income generation, in communities like Syringavale. As such, many households prioritise cultivating crops that they perceive to be more economically viable, nutritionally superior and more flexible for daily diets [3].

Factors influencing Bambara groundnut consumption

The factors that influenced BGN consumption in Syringavale are presented in Table 3. A majority of the respondents (54%) reported that the price of BGN seldomly influenced BGN consumption, while 40% of the respondents never considered price as a factor and 6% always considered it. Cultural beliefs were an integral part of the community and were considered highly influential, as all respondents (100%) took culture into account when considering the consumption of BGN, with 92% always considering it and 8% seldom considering it. The availability of BGN also played a significant role in its consumption pattern, with 92% always considering it and 8% seldom doing so. Additionally, respondents (6% always considered this factor, 80% seldom considered it and 14% never considered it) acknowledged the significance of diversity in the marketplace and stated how the presence of other options affected the consumption of BGN.

Threats to Bambara groundnut consumption

Distinct patterns in the perceived threats to BGN cultivation among respondents were observed and the findings are presented in Table 3. Weather was considered a threat by all respondents (100%) with 66% always considering it a threat and 35% seldom doing so. The respondents stated that heavy amounts of rainfall led to the rotting of seeds, thus significantly reducing yield. Although the BGN plant can tolerate heavy rains at the growing stage, at maturity, heavy rainfall results in seeds rotting [33]. Excessive rainfall, particularly during the maturation or harvest stages of BGN, can lead to waterlogging, resulting in reduced yields [22]. Respondents detailed that in subsequent bad seasons, where no BGN was harvested, there would be no planting seed available for the next season resulting in some respondents not cultivating BGN at all. Lack of funds was not identified as a prevalent threat, with 58% of the respondents seldomly considering it and 38% never considering it. The respondents (96%) who seldom and never considered lack of funds as a threat said they kept seeds from the previous harvest for the next planting season and did not spend money on growing BGN as it does not require fertilisers, chemicals or irrigation. Urbanisation was unanimously regarded as a persistent threat, with 100% of respondents always acknowledging it.

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Respondents specified that, because of urbanisation, households were smaller resulting in less labour and demand, therefore, a smaller acreage was allocated to the cultivation of BGN. The expertise of respondents was generally perceived as a minor threat to BGN, with 92% reporting that they seldom considered a lack of farming skill as a threat, while 8% acknowledged it as a constant concern. Recognising that insufficient knowledge on planting, earthing up and harvesting techniques for BGN could lead to poor yields, it is notable that all respondents (100%) demonstrated adequate knowledge in the agronomical practices of cultivating, growing, harvesting and storing BGN. This proficiency was attributed to the intergenerational transmission of farming knowledge and participation in community-based training workshops facilitated by Agritex officers.

Uses of the Bambara groundnut plant

The uses of the BGN plant and its components are presented in Figure 2. The responses provided a clear understanding of the various applications of BGN within the community, offering insights into its diverse roles.

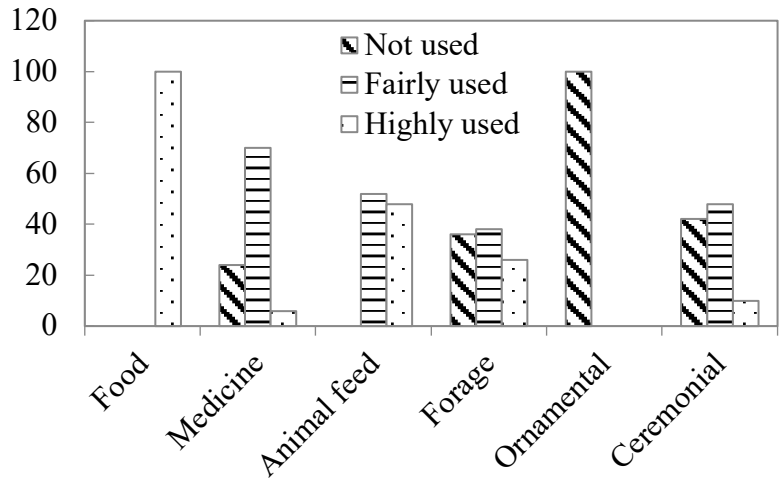

Figure 2: Uses of the Bambara groundnut plant

All respondents (100%) used the BGN seed for dietary purposes and noted both its palatable taste and satiating effect, with a minimum frequency of consumption being once a week. All respondents (100%) expressed a preference for the mature green seed (Figure 3a) over the dried seed (Figure 3b), citing short cooking time, energy saving and superior taste as reasons. Fresh mature green BGN seeds were said to take under an hour to boil while dry seeds took 3-4 h, requiring soaking overnight and consuming a considerable amount of firewood during the cooking process. The hard-to-cook characteristic of the dry BGN seed has commonly been stated as a constraint to its usage [8, 12, 34]. The hard-to-cook characteristic in legumes involves structural changes like cytoplasmic organelle autolysis and middle lamella lignification [3]. Additionally, it includes compositional

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changes such as insoluble pectate formation and interactions between proteins and phenolic compounds in cotyledons and seed coats [12, 34].

Bambara groundnut was reported to possess medicinal properties and to be a useful component of traditional medicine in the Syringavale community. Of the respondents, 24% indicated non-utilisation, 70% reported fair usage and 6% claimed complete non-usage for medicinal purposes (Figure 2). The leaves and seeds of BGN were utilised by 76% of the respondents for treating various conditions, including ear infections, lung conditions, heart diseases, kwashiorkor, nausea and infertility. For ear infections, respondents mentioned heating the dry seeds on a metal plate and applying the extracted oil to the affected ear/s. For lung and heart conditions, BGN seeds were boiled, mashed into a porridge and fed to the patient. To treat diarrhoea, BGN seeds were boiled with maize kernels and the water from the mixture was given to the patient. Furthermore, pregnant women were advised to chew and swallow the raw seed to alleviate morning sickness. Treatment for infertility or underdeveloped reproductive organs, particularly in males, involved crushing seeds and leaves, mixing them with other traditional herbs, and ingesting the juice. Some respondents (4%) emphasised the significance of BGN in preventing protein-energy malnutrition (PEM), commonly known as kwashiorkor, among infants in the community. Mashed BGN meal was encouraged for infants, contributing to the community's efforts to combat PEM, a major cause of infant mortality worldwide, particularly in developing countries [35]. The contribution of BGN to curbing PEM can be attributed to the high protein content of BGN (17-28%) [7, 35]. The medicinal properties of BGN are attributed to the presence of polyphenolic compounds associated with therapeutic benefits, along with its high nutritional profile, useful in combating malnutrition-related conditions [36, 37, 38]. Several studies in rural communities in Africa have reported medicinal properties of BGN [5, 29, 39, 40, 41].
Bambara groundnut was also useful in traditional tribal ceremonies with 42% of the respondents reporting non-usage, 48% indicating fair usage and 10% reporting high usage. In the tribal ceremony of strengthening a baby's fontanelle, BGN seeds were said to be roasted, ground, mixed with other herbs and smeared on the baby's head.

All the respondents (100%) indicated that they used the BGN plant as animal feed, with 52% of the respondents reporting fair usage and 48% indicating high usage. For use as forage, 36% of the respondents reported non-usage, 38% acknowledged fair usage and 26% reported high usage. For animal feed, BGN pods and leaves were utilised, occasionally blended with millet and maize husks. None of the respondents (0%) used BGN for ornamental purposes.

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a b

Figure 3: Bambara groundnut seeds; a) Mature green seeds, b) Dry seeds

Cooking methods and food uses of Bambara groundnut

Bambara groundnut seeds were processed and consumed in various ways in the Syringavale community. Several preparation methods of BGN were reported by respondents (Figure 4). Common dishes made from BGN mentioned by respondents are presented in Table 4. Boiling was the predominant method used for cooking BGN, with 100% of respondents stating it as highly used. Dry and mature green seeds were the most commonly consumed dishes as reported by 100% of the respondents.

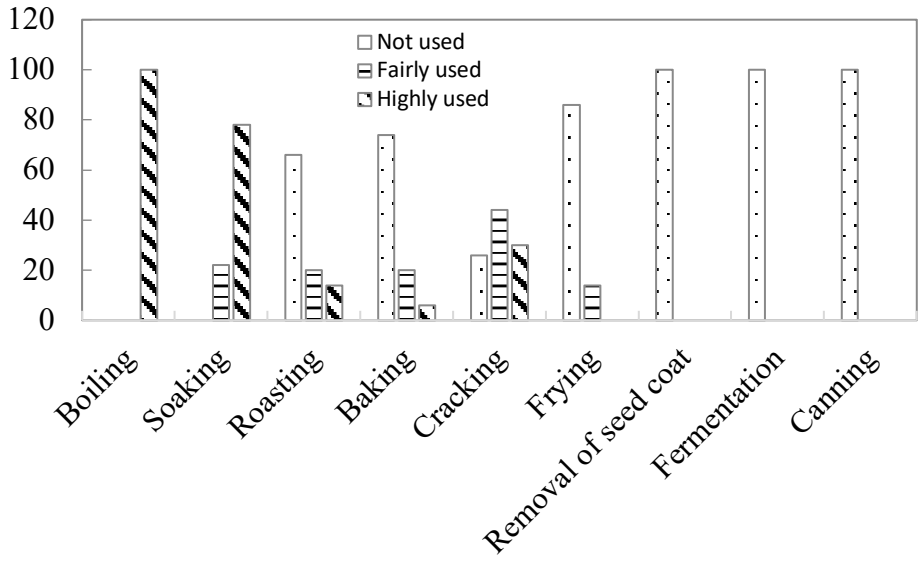

Figure 4: Main cooking methods for Bambara groundnut

Mature green seeds were boiled in their pods while dry seeds were shelled. Both were boiled with salt and eaten as they were or mixed with peanuts, maize kernels,

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maize meal and samp to make a variety of dishes. All boiled dishes were reported as common accompaniments for tea.

Overnight soaking was commonly used on dry seeds before cooking by all respondents (100%), with 78% of the respondents stating it as highly used and 22% as fairly used. Soaking BGN seeds before cooking allows them to absorb water, leading to swelling and softening of the seed coats. This hydration process reduces cooking time by breaking down the rigid cell structure, enabling quicker and more even cooking [3]. Moreover, soaking contributes to the inactivation of enzymes, leaching of water-soluble compounds and enhancement of overall digestibility, thereby optimising the efficiency of the cooking process and making BGN seeds easier to digest [42].

Baking was not a prevalent cooking method among respondents with 74% reporting it as not used, 20% as fairly used and 6% as highly used. Similarly, frying was not a common cooking practice among the respondents, with 86% indicating it as not used and 14% as fairly used. Respondents (26%) who used baking as a cooking method ground BGN seeds into flour for use in several dishes such as porridge, soups and baked products. This was similar to some cooking practices across Africa where BGN flour is used to make bread, cakes, soups, dumplings, porridge, fried cake balls and steamed products like *okpa* [2, 43, 44].

Cracking was reported for specific dishes, serving the purpose of reducing cooking time and addressing the hard-to-cook nature of cooking dry BGN seeds. Among the respondents, 26% indicated not using cracking, 44% reported fairly using it and 30% highly using it.

Respondents (14%) mentioned frying boiled seeds, in a similar manner to sugar beans, with tomatoes and onions to prepare a relish served with the staple food *isitshwala* (thick porridge made from maize meal, millet or sorghum flour) or rice. Similarly, BGN seeds were fried to create a relish, with or without condiments, reflecting a culinary tradition observed across Africa [45].

Practices such as removal of the seed coat, fermentation and canning were unanimously reported as not used by all respondents (100%), emphasising the specific and limited processing approaches applied to BGN in the community. Of the respondents, 2% recalled seeing canned BGN years ago in a supermarket in Harare, Zimbabwe. While canned BGN was once available in urban supermarkets in Zimbabwe, it was discontinued due to its high cost, rendering it unaffordable for the majority of the population [46].

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Marketing of Bambara groundnut

Although the study population comprised of subsistence farmers, 46% of the respondents reported occasionally selling BGN in the open market and 6% selling to wholesalers in the city of Bulawayo, Zimbabwe. Respondents involved in selling BGN highlighted that despite pricing the seeds at US$5 per kg, they did not generate substantial income due to the limited quantity sold. This corroborates the assertion that BGN is primarily cultivated for human consumption at the household level, with little or no income generated from its trade [1]. A market visit to Bulawayo, Zimbabwe revealed BGN prices ranging between US$4-$6 per kg in the open market and US$6 in supermarkets. Comparatively, the average cost of cowpeas and groundnuts were US$1 and US$2 per kg, respectively. The relatively higher price (US$4-$6) for BGN underscores its potential as an income-generating crop, suggesting the need for increased priority and allocation of more acreage. All the vendors visited sold mixed seeds without implementing a grading system. They mentioned that dry BGN seeds were available throughout the year, whereas mature green seeds were only available during the harvesting season. They noted that the season did not impact the price of BGN but mature green seeds were comparatively more expensive, as fewer seeds in shells filled a 5 Litre bucket than shelled dry seeds. Figure 5 shows BGN for sale in an open market.

Figure 5: Bambara groundnut on sale in an open market

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Taboos, stories and superstition associated with Bambara groundnut

Taboos, stories and superstitions associated with BGN, that were reported by the respondents, are reported in Table 5. Respondents (86%) reported that if BGN crops were not earthed up at the flowering stage, then males could not consume the seeds to avoid infertility. Additionally, respondents explained that males should not engage in weeding unearthed BGN crops, with 8% stating that males should not cultivate BGN at all. Some respondents (2%) stated that, apart from becoming infertile, if males cultivated BGN, the crop would not yield. These superstitions could explain why BGN has been labelled a 'woman's crop' [20, 47] as males are hugely restricted from cultivating or even consuming the crop. To avoid these superstitions coming true, the respondents (88%) stated that males weeding BGN had to tie the leaves of BGN around their waists.

All respondents (100%) emphasised that BGN crops must be weeded by hand, otherwise they would not yield. This could be responsible for the low production of BGN given the labour-intensive nature of manual weeding. The BGN crop grows close to the ground making it difficult to harvest mechanically. As such, weeding by hand, especially at the flowering stage, is emphasised as the flower stalks are very fragile and susceptible to breaking with rough handling [DAFF]. Not earthing up BGN crops as well as jumping over the crop was also said to stop the crops from yielding. Earthing up is carried out to cover up the exposed flowers in order to improve yield. The superstition about 'not jumping over the crop' could serve to discourage children from playing near BGN crop ridges, reducing the risk of potential damage to the crops.

All respondents (100%) reported that the consumption of BGN was sometimes accompanied by discomforts such as bloating, constipation, stomach pains and flatulence. To alleviate constipation and bloating, respondents mentioned rubbing the stomach repeatedly after consuming BGN and soaking the seeds before cooking. These discomforts are likely attributed to the presence of oligosaccharides in BGN, which remain undigested in the human gastrointestinal canal, reaching the colon where resident microbiota metabolise them, producing significant amounts of carbon dioxide, hydrogen and methane [12, 47]. These gases can lead to bloating and are expelled from the body as flatulence. Rubbing the stomach may aid peristalsis, thereby reducing stomach discomforts [3].

Some respondents (10%) mentioned that they sprinkled BGN leaves with ash when they showed signs of wilting or turned yellow before maturity. This was said to help maintain the crop and seeds till full maturity. Applying ash on stored BGN seeds has been reported to protect them from pests and insect infestations [21, 46]. Furthermore, to improve BGN yield, some respondents (6%) indicated the use of a branch of a white berry bush (*Flueggea virosa*) to beat the crops, then left in

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the field. The practice was believed to yield the best results if carried out before sunrise or by people with six fingers. Some respondents (2%) mentioned that BGN seeds could be employed to ward off witchcraft and also used for love portions.

Taboos, cultural beliefs and superstitions play a big role in hindering the production, marketing and consumption of BGN in many communities [48]. Across Africa, BGN is associated with death, protection, fertility and love, and is widely used in traditional medicine and witchcraft [29, 48, 49, 50]. As such, it is important to understand such beliefs when designing interventions to enhance local value chains, especially from a gender perspective.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

This study investigated the significance of BGN in the Syringavale community, providing insight into its cultivation, perceptions and uses. The research highlighted the influence of socio-demographic factors on BGN production and marketing. Bambara groundnut is primarily cultivated at household level by married women over the age of 40 and it plays a pivotal role in the community, fulfilling dietary, medicinal, animal feed and ceremonial uses. Rural areas are predominantly populated by women and children as many men migrate for employment. Furthermore, superstitions and traditional beliefs significantly hinder the involvement of men in BGN cultivation and consumption. This limited involvement of men in BGN production explains the significant role BGN plays in the socioeconomic lives of women. Different components of the BGN crop, such as the seeds, leaves, pods, flowers and roots served various purposes in the community. These components served as food, fodder, medicine, compost and played essential roles in traditional ceremonies. Moreover, the yellowing of leaves served as an indicator for harvest maturity, flowers served as indicators for the commencement of earthing up and roots contributed to soil fertility. Boiling, soaking, roasting, baking, cracking and frying were the cooking methods used in Syringavale. Respondents showed a preference for the mature green seed over the dry seed due to the significant time and energy consumption associated with cooking the latter. Despite its significance in the community, the study identified several challenges affecting the production, utilisation and consumption of BGN, such as small acreage allocation, weather, urbanisation, cultural beliefs, superstitions and market dynamics. Recognising BGN's immense potential to contribute to food security and the alleviation of poverty and malnutrition, particularly in impoverished communities like Syringavale, highlights the necessity for educational initiatives. Educating rural communities about the nutritional benefits of BGN could positively impact these areas, given their heavy reliance on locally produced food. In addition to offering food relief, it is recommended that non-governmental organisations conduct workshops on the nutritional benefits of

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BGN and how to reduce cooking time of dry seeds. These sessions can include guidance on how to pair BGN with other commonly consumed crops in the community to achieve a balanced diet. The government, facilitated by Agritex, is advised not only to educate local farmers on agricultural practices related to BGN but also to emphasise its nutritional and economic potential. To prevent the sharing and recycling of low-quality seeds within the community, Agritex officers could extend their seed distribution to include BGN, similar to what is done for major crops like maize. Additionally, the government could consider purchasing BGN from farmers or providing incentives to encourage increased acreage allocation.

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Table 1: Themes and subthemes of respondents' demographics and perspectives on Bambara groundnut

Themes	Sub-themes
Demographic and socioeconomic characteristics	• Ethnicity • Gender • Marital status • Age • Economic status • Education • Employment status
Useful parts of BGN plant	• Leaf • Flower • Root • Seed • Pod
Uses of BGN plant	• Food • Medicine • Animal feed • Forage • Ornamental • Ceremonial
Stage of the crop when used for food	• Immature green • Mature green • Dried seed
Cooking methods for BGN	• Cracking • Roasting • Soaking • Boiling • Baking • Removal of seed coat • Fermentation • Canning • Frying
Acquisition of BGN	• Grow in garden • Purchase • Gather from nature
Selling of BGN	• Open market • Supermarket • Wholesaler
Influencing factors on BGN consumption	• Price • Culture • Availability • Diversity in the marketplace
Threats to the abundance of BGN	• Weather • Lack of funds • Urbanisation • Unskilled farmers

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Table 2: Distribution of Bambara groundnut farmers' demographic characteristics

	Variables	Frequency	Percentage (%)
Ethnicity/Race	Black	50	100
Gender	Female	43	86
	Male	7	14
Marital status	Single	6	12
	Married	31	62
	Separated	3	6
	Widowed	10	20
Age	21-25	2	4
	26-30	5	10
	31-35	7	14
	36-40	13	26
	>40	23	46
Economic status	Poor	9	18
	Below average	27	54
	Average	11	22
	Affluent	3	6
Education	Illiterate	7	14
	Primary education	20	40
	Secondary education	18	36
	Diploma certificate	3	6
	Farming certificate	2	4

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Table 3: Factors affecting Bambara groundnut consumption in Syringavale, Zimbabwe

Acquisition of Bambara groundnut			
	Never (%)	**Seldom (%)**	**Always (%)**
Grown in own garden	0	0	100
Purchase	8	54	38
Gather from nature	100	0	0
Perceived factors influencing consumption of Bambara groundnut			
	Never (%)	**Seldom (%)**	**Always (%)**
Price	40	54	6
Culture	0	8	92
Availability	0	8	92
Diversity in the marketplace	14	80	6
Threats to Bambara groundnut			
	Never (%)	**Seldom (%)**	**Always (%)**
Weather	0	34	66
Lack of fund	38	58	4
Urbanisation	0	0	100
Unskilled farmers	0	92	8

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Table 4: Common dishes made from Bambara groundnut in Syringavale, Zimbabwe

Food	Description	Percentage (%)
Dry seeds	Shelled seeds boiled, salt added near the end of the cooking time. Commonly eaten as a snack or accompaniment for tea.	100
Mature green seeds	Podded seeds boiled with salt. Great accompaniment for tea or eaten as they are.	100
Inkobe	Meal made from boiling a mixture of dry BGN seeds, shelled peanuts and maize kernels.	100
Isimoni	Same as *inkobe* but with maize meal added to make a stiff porridge, normally eaten with tea.	100
Mutakura	A meal prepared by boiling BGN seeds, stamped maize (samp) and *dobi* (ground peanuts).	100
Idobi	Same as *inkobe* but with ground peanuts used as a thickener to make a stiff porridge.	8
Relish	BGN seeds cooked with onions and tomatoes into a soup.	14

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Table 5: Taboos, stories and superstition associated with Bambara groundnut

Taboo	Percentage (%)
If BGN crops are not earthed up at flowering, then males cannot eat them as it will result in infertility	86
Males should not weed unearthed BGN crops	100
Males should tie leaves around their waist when weeding BGN otherwise the crop will not yield	88
BGN crops should be weeded by hand otherwise they will not yield	100
Eating BGN leads to bloating, stomach pains, flatulence and constipation	100
If BGN crops are not earthed up at flowering, they will not yield	88
Stepping on BGN pods results in chronic foot pains	50
If the leaves wilt or turn yellow before maturity, they must be sprayed with a solution of ash or sprinkled with ash	10
If males cultivate BGN, they become infertile	88
Rubbing the stomach repeatedly after consuming BGN avoids constipation	100
To improve yield, a branch of white berry bush is used to beat a sample of the crops then the branch is left in the field. Best results are obtained before sunrise and best done by people with six fingers	6
Soaking BGN seeds reduces cooking time and bloating	100
BGN can ward off witchcraft or be used for love portions (witchcraft)	2
If one jumps over BGN crops, they will not yield	50

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