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The Possibilities for Enhancing the Commercial Value of *Sorghum* in Botswana

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Abstract: *Sorghum* has the potential to alleviate hunger and contribute to cereal self sufficiency in Botswana. The *Sorghum* plant has physiological adaptation mechanism that makes it suitable for low rainfall areas. The opportunities for improving the commercial value of *Sorghum* depend on the fact that *Sorghum* can be used as food for humans and as feed for livestock. To make *Sorghum* popular, new product development needs to be undertaken and this include revival of indigenous dishes. As animal feed, *Sorghum* grain can be used for feedlot, dairy, poultry and pig diet formulation. However, innovative strategies need to be developed or adopted to improve the efficiency of utilizing *Sorghum* grain by ruminants and non-ruminants. In particular the question of low digestibility of *Sorghum* in non-ruminants diets due to tannins needs to be tackled. The crop residue from *Sorghum*, especially stover, is a valuable feed resource for ruminant livestock. When it is timely harvested it can partly or wholly replace grass hay in ruminants diets. If considered, the suggestions advocated by this paper would help enhance the value of *Sorghum*, which in turn would promote its production by farmers.

Key words: Commercial value, Botswana , alleviate hunger

INTRODUCTION

Sorghum is one of the main staple food crops for the worlds' poorest and most food-insecure people[1] But *Sorghum* as compared to maize is more drought tolerant[2]. The high physiological adaptation of *Sorghum* to acquire and retain moisture[3,4] has made it more genetically suited to hot and dry areas[1]. Meeke and Basson[4] reported that *Sorghum* plant has twice the amount of secondary roots on each primary root, which enables it to absorb moisture more effectively than other cereal crops such as maize. In addition, reduction of moisture loss is made possible by the low leaf transpiration rates, which are one half of that of maize[5]. Its ability to evade short droughts by going dormant and resuming growth as soon as there is sufficient moisture[5] is another adaptation mechanism for survival in low rainfall areas. These attributes makes *Sorghum* suitable for a country like Botswana and therefore calls for improvement of efficiency of its production.

There are opportunities to increase the product base made from *Sorghum*. These include refined flour, different brands of beer, infant foods, bread flour, breakfast cereals and pet foods. As livestock feed, *Sorghum* grain can be used to formulate ration for both .ruminants (pigs and poultry) and ruminants (sheep, goats and cattle). When harvested timely and processed for efficient utilization, by-products of *Sorghum* could be of value to animals. Due to the frequent drought in Botswana and given the unique agronomic features of *Sorghum*, the crop has a comparative advantage over other cereals. However, due to low prices offered to *Sorghum* producers there is no comparative cost advantage for farmers to increase production of *Sorghum*. If the status quo continues there would be a decline in *Sorghum* production and as such increase in imports and loss of revenue. A strategy needs to be developed that will enhance the value of *Sorghum*, which will in turn make farmers find it valuable to grow. *Sorghum* is a sleeping giant of Botswana cereal grain industry that needs to be awakened.

Improving Utilization of *Sorghum* as Human Food: In Botswana *Sorghum* is used to prepare porridge. The grain is dehulled and ground into flour. Establishment of the milling industry has made it possible that *Sorghum* flour is readily available in both urban and rural areas. However, the use of *Sorghum* flour is restricted to preparing porridge (*motogo* and *bogobe*) except with the recent advent of child weaning food. This lack of multiple use of *Sorghum* limits its demand. This in turn limits the amount farmers can produce and thus reduce their farm income. If the product base of *Sorghum* could be increased, the demand for *Sorghum* by consumers may be

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increased hence the farmers will be paid a realistic price for their produce. This may encourage increase in the area planted with *Sorghum*. This cascade of events will need a good marketing plan for the new products since consumers will not be familiar with them.

Opportunities to popularise *Sorghum* include the initiatives taken by Food Botswana and National Food Technology Research Centre by developing child weaning food and dried fermented flour (*ting*) , respectively. Traditionally, Batswana ferment *Sorghum* flour to produce both soft and stiff porridge and this process has to be done periodically in order to have a constant supply of *ting*. Problems encountered include slow fermentation during winter and growth of mould on the product. Dried *ting* (dried fermented flour) could be produced commercially where the culture starter quality could be adequately control and the product sold through supermarkets. Nicholson[6] mentioned *mosuthane*, which was proposed for use as a rice replacer. Other possibilities that need to be exploited include breakfast cereals that will compete with cornflakes. The development of pet food and livestock feed based on *Sorghum* grain is worth investigating.

Food Botswana has experimented with ways of producing bread flour from composite of wheat and *Sorghum* flour. In this way, the amount of wheat is spared and thus save the country's' foreign reserves. Already *Sorghum* grain is used to produce opaque beer on a commercial scale (*chibuku*) and finding other types of beer could expand this industry. In Nigeria many brands of beer with substantial content of local *Sorghum* has led to the establishment of small and medium malt industries[7].

The most important thing is to develop products which are of high quality and which could compete with maize, wheat and rice products. For instance Nicholson[6] proposed the production of highly refined *Sorghum* flour enriched with vitamins that will be comparable with maize meal. This then calls for a production of a high quality grains, hence *Sorghum* breeding should pay attention to flour quality. Research efforts at the Department of Agricultural Research has shown that the cultivar *Phofu* is high yielding and its excellent milling yield (80%) make it an ideal candidate for producing high quality flour. Its desirable flour colour and taste led to its high rating by local farmers. Besides good quality of its food products, *Phofu* also produced malt with high brewing power (*Sorghum* Diastic Value of 48), which was highest among local *Sorghum* varieties.

Trends in Utilization of *Sorghum* (as Human and Livestock Feed in Botswana): The importance of grain *Sorghum* as both an energy and protein source to humans and livestock is well recognized in the developing countries[8]. However, the use of *Sorghum* as feed for livestock is still low in Africa and this trend prevails in Botswana too. The income elasticities for livestock products and hence the derived demand for *Sorghum* as feed for livestock are generally positive and high. This situation occurs in developed countries where *Sorghum* is regarded as an inferior cereal when used as food. In Botswana as it is the case in the rest of Africa, though livestock products are important, the use of *Sorghum* grain as feed for livestock is low. There are two major reasons for this; grazing provides basic feed resource for ruminants and farmers still consider it as an inexhaustible source. Secondly, to use *Sorghum* as feed for livestock will compete with human needs.

The circumstances that are evolving which will force us to rethink the utilization of *Sorghum* are as follows; a) as human population increases, grazing land resources will shrink and will not meet livestock requirements. b) globalization of trade through open competition means that only high quality products will survive the competition. Botswana beef is marketed under preferential trade terms with the European Union and the likelihood of this arrangement to be discontinued exist. Therefore finishing off beef cattle (using *Sorghum*) in feedlot operation would seem a wise option if we want to produce high quality product c) feed ingredients for poultry and pigs especially maize is expensive to import and *Sorghum* grain that is grown locally will have to be used d) the use of *Sorghum* grain as feed and new food products will increase the products which would open new markets for *Sorghum* producers. If the value of *Sorghum* could be increased, the demand for it will increase. For example, one of the factors that have been identified to constrain dairy production in Botswana is shortage of feeds. Concentrates have been singled out as the most expensive component of dairy feeds, especially that they are imported. The use of *Sorghum* grain for ration formulation for dairy industry would probably enhance the value of *Sorghum* and improve its productivity. Increase in *Sorghum* production means an increase in stover. *Sorghum* stover is a valuable as a source of roughage for ruminants and this will provide *Sorghum* producers with more options of how to utilise their produce.

To avoid competition with human, second grade or varieties specially bred for livestock will need to be used. Then, the marketing structure should be set such that *Sorghum* grain for different uses be allocated and priced according to quality and demand. The livestock-arable mixed farmers will then weigh the economics of either selling their *Sorghum* grain or using it to feed their livestock. This then calls for development of livestock ration based on *Sorghum* grain.

New Products: As human food, it is essential that innovative strategies are put into place by food scientists to develop new products such as biscuits, breakfast cereals, rice replacer (*mosuthane*), snacks and a brilliant promotion and market research need to be pursued. Details would need to be paid to taste and packaging to make the new products trendy and to have an appeal to the consumers. In livestock industry, possibilities include those already mentioned; pet food, feedlot rations, dairy concentrates, poultry and pig feeds.

***Sorghum* Grain Quality as Regards to Livestock Feeding:** Feed characteristics of *Sorghum* grain are very similar[1,2,9] or even better than maize Mitzner *et. al.*).[10] *Sorghum* grain has lower fat content (21 vs. 38 g kg^{-1}) but is higher in crude protein 110 vs. 88 g kg^{-1}[11] and contains high percentages of starch[1,10] than maize. However, because of its low starch digestibility[9-12] *Sorghum* grain is often considered to have lower feeding value than maize[1,10] especially for non-ruminant livestock. This is encountered when the cultivars have high-condensed tannins[1,13].

The low digestibility of *Sorghum* comes from starch-protein matrix, which is more resistant to moisture and enzyme penetration than that in maize and other grains[9-12]. According to Rooney and Pflugfelder[9] starch exists inside the endosperm of cereal enmeshed in a protein matrix. *Sorghum* has also higher amount of intermolecular cross-links called kafrinis found in *Sorghum* prolamines that decrease digestibility of protein and starch granules[11].

Given this problem of low digestibility of *Sorghum* grain in ruminant feeding, a strategy of increasing the feeding value must focus in disrupting or destroying the structures that prevent the animal endogenous digestive enzymes from attacking the nutrients[11]. An alternative strategy would be to breed varieties with increased protein and starch digestibility[11,12]. The use of synthetic *Sorghum* specific enzymes was proposed by Bravo [11] as another alternative method of enhancing the feeding value of *Sorghum* grains. These enzymes would aid digestibility by degrading certain physical barrier to digestion.

According to Rooney and Pflugfelder[12] the presence of waxy trait in *Sorghum* generally improves the feeding value of the grain over normal endosperm varieties. This is because the waxy varieties of *Sorghum* have almost all of their starch as the branched glucose polymer[11] and are better digested. Involvement of plant breeders in improving the feeding value of *Sorghum* will go a long way in providing alternative use for *Sorghum*. Thus livestock producers (and feed millers) could contract for waxy type *Sorghum* and be assured of obtaining the high feeding value that these hybrids offer[12]. Another trait in *Sorghum* that has been found to influence feeding value is the bird-resistant trait. A study by Streeter *et. al.*,[21] showed that bird-resistant *Sorghum* types had greater intake of total, essential and non-essential amino acids than non-bird resistant varieties. Greater condensed tannin content of bird-resistant than of non-bird resistant grain caused decreased destruction of amino acids in the rumen. Tannin-containing cultivars are preferred because of the protective nature of tannins against the birds and mold infestation[8]. Indigenous *Sorghum* types which have been selected over many years have this trait but may find themselves been gradually replaced by high yielding hybrids with no bird-resistant trait. The development of new *Sorghum* hybrids with these traits may increase *Sorghum* feeding efficiency and hence its value as a crop to *Sorghum* producers. However, for non-ruminants like poultry and swine, tannins are a constraint on the utilization of *Sorghum* grain as feed [1,13].

Processing of *Sorghum* for Livestock Feed: Processing improves feed efficiency by disrupting the peripheral and corneous endosperm cells of *Sorghum* kernel to expose the components to digestive enzymes[14]. Rooney and Pflugfelder[12] mentioned steam-flaking, popping, reconstitution plus grinding and early harvesting plus grinding as methods that are able to improve the nutritional value to levels comparable to maize. According to Chen *et. al.*,[9] starch hydrolyzation from steam-flaked maize and steam-flaked *Sorghum* grains was similar and both increased milk yield, milk fat and protein. When comparing *Sorghum* with maize Mitzner *et. al.*[10] found that finely ground grain yielded more milk than cows fed rolled grains and dry matter intake was not affected by source of grain.

Both reconstitution and early harvesting improve digestibility without the application of heat to gelatinise starch. Reconstitution causes fermentation degradation of the matrix while early harvested grain is utilised before the starch-protein matrix is completely formed and solidified[12]. For early-harvested high moisture grains, the protein matrix is not tightly bound to the starch because the endosperm is never allowed to dry and starch granules are released from the protein during grinding [15]. The process of brewing traditional beer with *Sorghum* involves malt formation and is similar to reconstitution. This indigenous knowledge could be adapted to suit livestock feed production from *Sorghum*. Ambula *et. al.*, [1] suggested the use of polyvinylpyrrolidone, a tannin binder, as ameliorating agent that would improve performance of chick fed high tannin *Sorghum*. According to Nyachoti *et. al.,*[8] diets formatted to contain high protein levels and an appropriate balance of amino acids will also improve chicken performance.

The Value of *Sorghum* Stover: Utilization of crop residues in fodder-flow programmes of animal production systems can make an important contribution in achieving an effective integration of crop-animal production practices[16]. However the nutritive value of *Sorghum* stover is generally low. APRU[17] reported values of crude protein ranging from 23 to 63 g kg^{-1} and so could not be used as a sole feed for animals. Snyman and Joubert [15] found that different forms of *Sorghum* stover; fresh, silage, hay and frosted had crude protein levels of 65, 65, 58 and 60 g kg^{-1} , respectively. This indicates the importance of timeliness of harvesting of stover. With the arrival of new varieties and hybrids that are leafy and have the ability to produce tillers after grain harvesting, high levels of crude protein (90g kg^{-1}) have been recorded[18]. An amount of 70 g kg^{-1} is needed for body maintenance of mature cattle in the tropics. Becker and Einfeldt[19] have suggested that identifying available *Sorghum* varieties with better fodder value (e.g. high leave ratio) and making deliberate breeding measures would be worthy research effort.

Some advantages can be gained if *Sorghum* stover can be used in ruminant diets. A report by Central Statistics Office[20] estimated that in 1995, a total of 113,547 tonnes of *Sorghum* grain was produced by both the traditional and commercial sectors. The amounts of available cereal crop residues could be estimated from grain yield. Assuming a ratio of 1:5 of grain to stover [21], stover production in 1995 would be 567 735 tonnes. However, the stover is usually not used effectively since animals are allowed to graze it in the fields and in the process, waste it due to trampling. Stover can replace part or all of the roughage needed by the ruminant animal provided the feeding value is improved by ammonia or urea treatment or judicious supplementation with on-farm generated leguminous forage like *Lablab purpureus*. For instance assuming that a beef steer in a feedlot with an initial weight of 280kg eats 10kg/day of a feed ration that contains 40% *Sorghum* stover. If this ration is fed for 90days for a reasonable gain of 1kg/day, then 567 735 tonnes of stover produced in 1995 minus 20% refusals, would have supported 1 261 633 steers which would have yielded good quality beef when send for slaughter.

As a conclusion, *Sorghum* is truly a dual-purpose crop, as both the grain and stover can be used as food and feed. The prospects for expanding *Sorghum* use as a feed grain depend largely on the location of the stock feed industry relative to production areas and the speed of its expansion. Once food demands are met, the prospects for growth in feed demand are high[1] and thus its value will increase.

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REFERENCES

1. Food and Agric. Organisation (FAO) and International Crops Research Institute for Semi-arid Tropics (ICRISAT), 1996. The world *Sorghum* and millet economics; facts, trends and outlook FAO and ICRISAT, pp: 5-25.
2. Ambula, M.K., G.W. Oduho and J.K. Tuitoek, 2001. Effects of sorhgum tannins, a tannin binder (Polyvinylprrolidone) and *Sorghum* inclusion level on the performance of broiler chicks. Asian-Australasian J. Animal Sci., 14:1276-1281.
3. Crawfurd, P.Q. and J.M. Peacork, 1993. Effects of heat and drought stress on *Sorghum* (*Sorghum bicolor*) II Grain Yield. Experimental Agric., 29: 77-86.
4. Meeske, R. and H.M. Basson, 1995. Research Note: Maize and forage *Sorghum* as silage crops under drought conditions. African J. Range and Forage Sci., 12: 133-134.
5. Black, J.R., L.O. Ely, M.E. McCullough and E.M. Sudweeks, 1980. Effect of stage of maturity and silage additives upon the yield of gross and digestible energy in *Sorghum* silage J. Animal Sci., 50: 617-624.
6. Nicholson, N.F., 1992. Processing of *Sorghum* in Botswana for foods and seeds: Problems and opportunities. In Utilisation of *Sorghum* and millets. (Eds) M.I. Gomez, L.R. House, L.W. Rooney and D.A.V. Dendy. International Crops Research Institute for the Semi-arid Tropics, India, pp: 99-101.
7. Aribisala, A.O., 1990. Industrial utilisation of *Sorghum* in Nigeria. In Industrial utilisation of *Sorghum*. Summary of proceedings of a symposium on the current status and potential of industrial uses of *Sorghum* in Nigeria. 4-6th December 1989, Kano, Nigeria. ICRISAT.
8. Nyachoti, C.M., J.I. Atkinson and S. Leeson, 1998. Evaluation of Magadi soda-treated *Sorghum* grain for young broilers. Animal Feed Sci. Technol., 70: 295-304.

9. Chen, K.H., J.T. Huber, C.B. Theurer, R.S. Swingle, J. Simas, S.C. Chan, Z. Wu and J.L. Sullivan, 1994. Effect of steam flaking of corn and *Sorghum* grains on performance of lactating cows. J. Dairy Sci., 77: 1038-1043.
10. Mitzner, K.C., F.G. Owen and R.J. Grant, 1994. Comparison of *Sorghum* and corn grains in early and midlactation diets for dairy cows. J. Dairy Sci., 77: 1044-1051.
11. Bravo, F.O., 1994. Increasing the feeding value of *Sorghum*. Feed Management, 45:6-13.
12. Rooney, L.W. and R.L. Pflugfelder, 1986. Factors affecting starch digestibility with special emphasis on *Sorghum* and corn. J. Animal Sci., 63: 1607-1623.
13. Lizardo, R., J. Peiniau and A. Aumaitre, 1995. Effect of *Sorghum* on performance, digestibility of dietary components and activities of pancreatic and intestinal enzymes in the weaned piglet. Animal Feed Sci. Technol., 56: 67-82.
14. Rooney, L.W., 1990. Methods of processing *Sorghum* for livestock feeds. In: Industrial Utilisation of *Sorghum*. Summary of proceedings of a symposium on the current status and potential of industrial uses of *Sorghum* in Nigeria., Kano, Nigeria. ICRISAT.
15. Rooney, L.W., 1992. Methods of processing *Sorghum* for livestock feeds. In: Utilisation of *Sorghum* and millets. (Eds) M.I. Gomez, L.R. House, L.W. Rooney and D. A. V. Dendy. International Crops Research Institute for the Semi-arid Tropics, India, pp: 167-177.
16. Snyman, L.D. and H.W. Joubert, 1995. Chemical composition and in vitro dry matter digestibility of various utilisation forms of grain *Sorghum* residues. African J. Range and Forage Sci., 12: 116-120.
17. Animal Production Research Unit (APRU), 1980. Potential of crop residues In Ten years of animal production and range research in Botswana.
18. Madibela, O.R., T.D. Pelaelo, I. Raditedu and J. Macala, 2000. Availability and utilisation of feed for livestock at farm level (unpublished). Government printers, Gaborone, pp: 112-116.
19. Becker, K. and C. Einfeldt, 1990. Multiple use of cultivated plants; straw utilisation in animal nutrition-indications for plant breeding. Experimental Agriculture, 26: 279-286.
20. Central Statistics Office (CSO), 1999 and 1995. Botswana Agricultural Survey Report. Ministry of Finance and Development Planning and Ministry of Agric. Department of Printing and Publishing Services, Gaborone.
21. Kossila, V., 1988. The availability of crop residues in developing countries in relation to livestock populations. In Plant breeding and nutritive value of crop residues (Eds) J.D. Reed, B.S. Capper and P.J.H. Neate, Proceedings of a workshop held at ILCA Addis Ababa. Ethiopia, ILCA Addis Ababa, pp: 29-39.
21. Streeter, M.N., G.M. Hill, D.G. Wagner, F.N. Owens and C.A. Hibberd, 1993. Effect of bird-resistant and non-bird-resistant *Sorghum* grain on amino acid digestion by beef heifers. J. Animal Sci., 71: 1648-1656.