1. GENERAL INTRODUCTION

Zimbabwe with a total area of 390,760 km^2, is divided into five agro-ecological zones based on rainfall and soil types (Nyamapfene 1991). Natural regions I and II, receiving >750 mm of rainfall per annum, are suitable for annual cropping and intensive agriculture. The rest of the regions receive less than < 750 mm of rainfall per annum. In general rainfall decreases from the eastern to the western parts of the country. Natural regions III, IV and V, where 65% of Zimbabwe's 10 million people live, have low and erratic rainfall with severe mid-season dry spells, which consistently result in maize crop failure. The lack of food security in these regions is partly caused by the use of maize, which is less suitable than more drought tolerant crops such as sorghum (SADC/ICRISAT Annual Report 1990). Shumba (1993) indicated that sorghum production is increasing in communal areas of Zimbabwe, but utilisation is not expanding. Obilana (1997) cited lack of information on the usability and nutritional qualities as one of the reasons for under-utilisation of sorghum grain. Sorghum grain has traditionally been milled for porridge, boiled like rice, or malted for sour, non-alcoholic and alcoholic beverages. The major commercial use of sorghum is in the industrial brewing of traditional opaque beer. DC-75, a high-tannin sorghum hybrid, has been the major variety promoted by the leading Zimbabwean opaque-brewing company, the latter of which engages contract farming to get its grain supplies. The move towards contract farming has left the Grain Marketing Board (GMB), a parastatal of the Zimbabwean government, with fewer markets for the polyphenol-rich sorghums. Apart from the opaque beer market, polyphenol-rich sorghums have not been processed for other major food products for the urban areas. Recently, small-scale millers have embarked on sorghum dry milling using grain of inconsistent quality. Market penetration has not yet been realized due to quality defects of the sorghum meal in comparison with the predominant maize meal from large-scale millers. Lacking markets, it remains a crop of the small cultivator, consumed largely on the land where it is produced. Research and development aimed at producing quality primary and secondary products from both tannin-free and polyphenol-rich grains for use by those who are not farmers, will remove this particular restraint on sorghum and would do much to offset Zimbabwe's shift in demand towards imported rice, wheat and maize. However, initial emphasis should be placed on understanding the biochemical components that constitute the grain and how they affect the desired food products.

Phenolic compounds comprise some of the important biochemical components found in sorghum. They include phenolic acids, flavonoids and condensed tannins (Hahn et al 1984), the latter two are grouped as polyphenols. Tannin-free sorghums contain phenolic acids and some flavonoids. Phenolic acids play a role in imparting resistance to fungal attack; the degree of resistance is linked to grain that contains both a greater variety and larger amounts in the free form (Hahn et al 1983). However, resistance to fungal attack is not solely attributed to phenolic acid content but to other physical grain characteristics as well (Hahn et al 1983). The flavonoid compounds are responsible for the colour of the pericarp of sorghum grains (Kambal & Bate-Smith 1976). Polyphenols protect sorghum grain against weathering (Harris and Burns 1973) and pre-harvest germination (Harris and Burns 1970). Tannins also impart a degree of bird and mould resistance or tolerance in sorghum grain (McMillan et al 1972; Hahn et al 1984). Thus the cultivation of polyphenol-rich sorghums reduces pre-harvest losses due to bird depredation and post-harvest storage losses. High-tannin sorghum varieties are preferred by some industrial sorghum maltsters (for example, in Zimbabwe, Botswana and South Africa) as the grain is more resistant to mould infection during the moist, warm conditions (95-100% RH, 25-30°C) used for malting. In Southern Africa, tannin deactivation using formaldehyde is achieved during malting of high-tannin sorghums (Daiber 1975a). During malting, Zimbabwean high-tannin sorghum varieties, DC-75 and Mutode can accumulate higher levels of reducing sugars and free amino nitrogen (FAN) compared to the low tannin varieties, SV2 and Chihumani (Bvochora et al 1999).

The presence of phenolic compounds in sorghum has, however, some negative implications. Phenolic acids do not affect nutritional quality of sorghum grain but may form undesirable colours during maturation as well as under some food processing conditions, for example under alkaline conditions (Hahn et al 1984). Flavonoids and phenolic acids would be undesirable in sorghum flour and meal if the products are meant to compete with their white maize and wheat counterparts in urban markets. The condensed tannins in sorghum are the only group of phenolic compounds that bind proteins reducing nutritional value (Hahn et al 1984). Tannins are able to bind more strongly to large proteins and to proteins high in proline (Butler 1982). They inhibit all enzymes in *in vitro* assays (Hagerman & Butler 1981). The non-specificity of their ability to bind protein could be the reason behind the general lack of evidence that tannins could be deactivated. Tannin-containing sorghum produces malt of lower quality (Daiber 1975a; Chavan et al 1981; Daiber and Taylor 1982) as the tannins will inhibit the amylase enzymes required for starch hydrolysis once the milled malt is mixed with water. Tannins inhibit growth and fermentation of some microorganisms and hence could influence the balance of the fermentation medium (Strumeyer and Malin 1975). Studies using sorghum have shown that tannins diminish growth rates, protein digestibility, and feed efficiency in rats (Jambunathan & Mertz 1973), hamsters (Mehansho et al 1987), swine (Cousins et al 1981; Knabe 1990), and poultry (Muindi & Thomke 1981; Sell et al 1983). High-tannin sorghum varieties are most often very soft (Chibber et al 1980; Waniska et al 1989) probably because they have not been required to develop the hard grain trait when already equipped with the protection given by the polyphenols. Polyphenol-rich sorghum presents challenges in food processing and deactivation methods using acid or alkali (Reichert et al 1980), and formaldehyde (Daiber 1975) have been proposed.

Polyphenols play important agronomic roles but their negative implications as regards the food value of sorghum present several challenges. Firstly, there is need to retain, and even enhance, the beneficial effects of sorghum phenolic compounds in the ecosystem. Secondly, the anti-nutritional effects of condensed tannins, also known as antifeedants (Mole 1986), need to be dealt with if the full food value of sorghum is to be realised. The agronomic advantages of sorghum tannins can be maintained if post-harvest food processing is used to reduce or deactivate the anti-nutritional polyphenols. Thirdly, while the simple polyphenols in sorghum grain are not anti-nutritional, they may impart undesirable colours to food products (Hahn et al 1984) making them less attractive. Success in food processing can diversify the uses of polyphenol-rich varieties and improve the nutritive value of high-tannin sorghums. Hence there is need for simple processes to enable utilisation of polyphenol-rich sorghums.