



Towards household food and nutrition security in semi-arid areas: What role for condensed tannin-rich ruminant feedstuffs?



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ABSTRACT

The global demand for food is projected to continue its upward trend for at least another 40 years while under-nutrition among infants, young children, and women remains a major problem. These challenges of food and nutrition insecurity are particularly pronounced in the semi-arid regions of the world. In semi-arid areas, ruminant animal production often represents the best option to meet the projected demand for food since crop production is constrained by erratic rainfall patterns. However, the productivity of ruminant animals in these semi-arid regions is generally accepted to be too low to meet the demand for animal products. This yield gap occurs due to various production constraints that will be explored in this review. Chief among these constraints is the fluctuation in quantity and quality of feed due to growing conditions that only support seasonal growth of grasses in rangelands. Complementing grasses as a source of feed for ruminant animals, is a collection of shrub and browse tree products that can be used during the long dry seasons. Although ubiquitous and, as such, a potential solution to feed shortages, browse products tend to contain secondary plant compounds especially tannins, whose effect on the nutrition of the ruminant is far from being unequivocal. Recent evidence also shows tannins improve composition, quality and shelf life of ruminant products. This review is designed to explore ways through which the beneficial nutritional effects of tannin-rich browse products can be maximized to plug the animal product yield and quality gap and improve food and nutrition security in semi-arid areas of low-income food-deficit countries.

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1. Introduction

Nearly one in seven people in the world do not have access to adequate dietary protein and energy while an even greater proportion suffers from micronutrient deficiency (FAO, 2009). The global prevalence of stunting, a symptom of chronic undernutrition in early life, stands at 26% (Black et al., 2013) while in semi-arid regions of the world, the prevalence is thought to be much higher (van Auerbeke & Khosa, 2007). The semi-arid areas of low-income food-deficit countries (LIFDCs) are home to the largest number of vulnerable and food and nutrition-insecure households (Milgroom & Giller, 2013; Sutherland, Irungu, Kang'ara, Muthamia, & Ouma, 1999). The UK Department for International Development's (DFID, 1994) Renewable Natural Resources Strategy defines semi-arid production systems as those that are "found in areas where the mean monthly temperature is above 18 °C and where there is one or more season during which evapotranspiration exceeds precipitation". These semi-arid regions have high

populations of small-scale, subsistence farmers and water availability is the major constraint to agricultural production. In these areas, food availability and malnutrition, especially among children, as well as diet-related chronic diseases in resource-poor families are a common occurrence (FAO, 2009).

Livelihoods in semi-arid areas are mainly centered on animal agriculture, with minimum crop production due to short rainy seasons and erratic rainfall patterns (Richardson & Hahn, 2007). As a result, crop failure is an endemic feature, particularly for the less-adapted crops while the more adapted crops like millet and sorghum do better (Sutherland et al., 1999). Animal production is, therefore, the main avenue through which families can attempt to reduce food and nutrition security risks caused by sub-optimal food production as well as institutional failures that cause suboptimal food distribution. It is important to boost meat production from rangelands in the semi-arid areas but this strategy is constrained by the cost of feeding animals, which often accounts for over 75% of the costs incurred in the rearing of animals. Since subsistence farmers in semi-arid areas are resource-poor, there is an inevitable challenge of access to animal feed from commercial suppliers. Rangelands in semi-arid areas are a potential source of less expensive, local feed resources in the form of grazing and/or browse products. Efficient utilization of browse products is, however, constrained by limited access to technical knowledge and skills required to minimize

Abbreviations: ADG, average daily weight gain; CT, condensed tannin; FA, fatty acids; LIFDCs, low-income food-deficit countries; PEG, polyethylene glycol; PUFA, polyunsaturated fatty acids.

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the antinutritional effects and maximize the beneficial effects of tannins that are commonly found in browse foliage. Tannins are ubiquitous in these feed resources because they are mainly produced in response to various environmental stress factors, particularly in those plants with inductive phenolic biosynthetic pathways (Barton, 2008; Estell, 2010). Tannins are a potential vehicle through which a number of food and nutrition security objectives can be met. They are known to have some potential in parasitic control (Min & Hart, 2003), enhanced protein nutrition (Barry & McNabb, 1999; Mlambo et al., 2004), mitigating enteric methane and ammonia emissions (Tiemann et al., 2008), and improving meat quality and fatty acid composition (Brojna et al., 2014; Luciano et al., 2009; Mapiye, Chimonyo, Dzama, Muchenje, & Strydom, 2010; Mapiye, Chimonyo, Dzama, et al., 2011), among other beneficial nutritional effects (Durmic & Blache, 2012).

The purpose of this review, therefore, is to examine the possible strategies through which tannin-rich ruminant feedstuffs can be used to facilitate sustainable intensification of ruminant animal production to salvage the precarious food and nutrition security situation that prevails in resource-poor, vulnerable communities in semi-arid areas of LIFDCs. Despite the common view that semi-arid areas are low-potential or marginal zones, we intend to demonstrate that there is potential for sustainable intensification of ruminant animal production based on the transfer of information on the appropriate use of locally available shrubs/browse leaves and fruits as feed resources.

2. Food and nutrition security in semi-arid regions

Food and nutrition security describes whether or not households have access to sufficient, safe, and nutritious food for a healthy and productive lifestyle (FAO, 2003). Sadly, the nature, extent, and dynamics of food and nutrition security at household level in semi-arid areas are not well-understood, despite concerted efforts at global level to reduce food and nutrition insecurity. In semi-arid areas, availability of water for crop and livestock production as well as other domestic uses is unpredictable. These areas are dominated by subsistence production units supported by low levels of technology. Therefore, it comes as no surprise that vulnerability to food and nutrition insecurity is very high among households in semi-arid areas of LIFDCs (Kirsten, Townsend, & Gibson, 1998; Milgroom & Giller, 2013; Sutherland et al., 1999; van Averbeke & Khosa, 2007). Sutherland et al. (1999) suggest that sustainable agricultural development should be based on a thorough understanding of the socio-economic and biophysical conditions of these areas – a location-specific approach rather than centralized, national-level development prescriptions.

A closer look at the economic activities in these areas will shed some light on the identity and dynamics of the principal determinants of food and nutrition security. Agriculture remains the major economic activity in semi-arid areas despite the perennial water shortages. Smallholder farming systems in semi-arid areas are made up of a variable mix of crop-livestock production, with greater emphasis on livestock production where rainfall patterns and amounts are more erratic. Livestock production is thus a major component of the agricultural economy of semi-arid areas, making contributions to food and nutrition security that go beyond the direct provision of food. Common animal agriculture activities include micro-livestock (poultry and pigs), small ruminants (sheep and goats), large ruminants (cattle) (van Averbeke & Khosa, 2007), and non-ruminant herbivores such as rabbits and donkeys. Of these animals, ruminants and donkeys are the most popular since they compete less with humans for food. These animals can be easily reared on plant forages that cannot be utilized by humans directly. It is also important to highlight that most of the land used to produce these animals are unsuitable for arable farming. Apart from their vital function as direct sources of food, animals also indirectly contribute to food and nutrition security by supplying traction and manure for cropping, income to purchase staple food, and creating jobs and business opportunities for the local population. It is a reasonable assumption

that an increase in the productivity of animals reared in semi-arid areas may translate into greater food and nutrition security for households and individuals. However, scholars often disagree on the importance of agricultural activities as contributors to food security in these regions, arguing that significant contributions can only be realized in areas where natural resources are conducive to successful crop production (Kirsten et al., 2003; van Averbeke & Khosa, 2007). By this logic, food and nutrition insecurity in semi-arid areas cannot be reduced by improving agricultural production. This unfortunate conclusion neglects the role that sustainable intensification of animal agriculture can play in these regions as a guarantor of food and nutrition security. The next section explores the potential of ruminant animal production in reducing food and nutrition insecurity in semi-arid areas.

3. Ruminant animal products and food and nutrition security

In developing countries, ruminant animal food products such as meat and milk represent the most concentrated source of minerals and vitamins, which are critical for infants, young children, and women (Godfray et al., 2010). Indeed, animal food products have higher biological values when used as human food compared to plant-based foodstuffs. Fanzo (2014) writes that a larger proportion of the world's population suffers more from micronutrient (vitamins and minerals) deficiencies than from hunger. These deficiencies cause adverse effects on maternal health and child survival and development (Micronutrient Initiative, 2009). Ruminant animal products contain a large proportion of these essential nutrients that may be deficient in cereal grains such as maize, sorghum, millet, wheat. The consumption of small amounts of ruminant animal products, in the form of meat or milk, can correct nutrient deficiencies in cereal-based human diets. In addition, animal proteins are more digestible and metabolized more efficiently than plant proteins (De Boer, Yazman, & Raun, 1994). An increase in the supply of animal products increases food security and dietary diversity, which may reduce undernutrition. In semi-arid areas, animal products are likely to be obtained from ruminant animals whose production is a better-fit for conditions that exist in these areas. However, it is not only food of animal origin that contributes to household food security but the monetary income that may be earned from sales of live animals and animal products. In fact, Kirsten et al. (1998) report that it is only when agricultural production has generated substantial monetary income or has enabled substantial reduction in household food expenditure that improved nutritional status of households is observed. Clearly, strategies that enhance the productivity of ruminant animals in semi-arid areas will enable farmers to produce surplus animals and animal products for sale to generate monetary income. Such strategies should be identified based on careful analysis of the constraints that farmers in semi-arid areas face as they attempt to increase the productivity of their animals. Production constraints include scarcity of drinking water, lack of extension services, diseases, lack of market for animals and their products, and recurrent cycle of drought (Onono, Wieland, & Rushton, 2013). Of these, the primary constraint that is frequently cited by farmers and researchers is the fluctuation in quality and quantity of feed (Mapiye, Chimonyo, Dzama, Raats, & Mapekula, 2009).

The nature of subsistence farming practiced in the semi-arid regions means that farmers cannot afford to purchase commercial feeds and supplements to use during the long dry seasons. As a result, animals lose weight or die during the dry season with the consequence of reduced production and product quality. Indeed, Hoffman, Cousins, Meyer, Petersen, and Hendricks (1999) report that in semi-arid areas, livestock populations fluctuate over time as reproductive and survival rates change in response to changes in the availability of forage. In order to reduce feeding costs, maintain animals through the dry season, and enhance production and product quality, we recommend increased reliance on non-conventional, locally available browse products, which can be used as protein supplements. However, browse products contain variable quantities of tannins and non-tannin phenolics (Mlambo et al.,

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