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Full Length Research Paper

The effect of soil chemical properties on basic gum composition

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Geographical Positioning System was used to mark the sites of *Acacia senegal* variety *kerensis* in Marsabit and Samburu districts. Soil and gum samples were collected for analysis of pH, carbon, nitrogen and phosphorus. Soil pH (6.0 - 6.7) varied significantly ($p < 0.05$) with pH of gum (4.54, 4.50, 4.51 and 4.52) in all the sites. In Merrile, organic carbon in gum (0.15%) was significantly higher than 0.073, 0.055 and 0.027% in Logologo, Laisamis and Sereolipi, respectively. Soil nitrogen (0.30, 0.4 and 0.8%) in Merrile, Laisamis and Logologo were significantly correlated ($p < 0.05$) to the nitrogen (0.31 - 0.32%) in gum, while soil N (0.3%) in Sereolipi was not significantly correlated with gum nitrogen (0.23%) and was significantly lower than those of Merrile, Laisamis and Logologo (0. 31, 0.32 and 0.32%). Phosphorus (700.2 and 705.2 ppm) in gums from Sereolipi and Merrile were significantly higher than 412.2 and 412.2 ppm in Laisamis and Logologo. pH (4.5 - 4.54) and nitrogen content (0.31 - 0.32%) in gum from Merrile, Laisamis and Logologo were within the international standards (pH 4.2 - 4.8) and (0.24 - 0.41%). Chemical properties of soils were major factors that influenced the gum quality.

Key words: *Acacia senegal*, soil, gum arabic quality, sites.

BACKGROUND AND JUSTIFICATION

Acacia senegal varieties are thorny and spiny trees, which grow abundantly in areas with annual rainfall of 200 - 800 mm and high temperatures in the arid and semi-arid lands of Marsabit and Samburu districts in northern Kenya. The tree plays an important role in enriching the fertility of the soil through biological nitrogen fixation. It has remarkable adaptability to drought. The tree produces gum arabic in form of nodules or tears, under internally controlled physiological process during the dry season and in poor soil conditions. Gum arabic exudate is produced through insect attack, mechanical injury or by making incisions in the stems and branches to strip away the bark to accelerate exudation. Gum arabic is used as an emulsifier and stabilizer in the food and pharmaceutical industries (Mocak et al.1998).Other industrial products that use technical grades of gum arabic include adhesives, textiles, printing, lithography, paints, paper sizing and pottery glazing.

Gum arabic is harvested by herdsmen and women groups from the natural stands of *Acacia senegal* varieties from different botanical sources, locations, and soil types, age of trees, seasons, topographical conditions and temperature (Chikamai and Gachathi, 1994). It has been reported that the quality of gum may be influenced by geographical origin and age of the trees, climatic conditions, soil environment, and even on the place of exudation on the tree (Chikamai, 1993; Idris et al., 1998; Islam et al., 1997; Karamalla et al., 1998). The quality of gum arabic must conform to international specifications (FAO 1995). Most concerned in this regard are the US Food and Drug Administration, the British Pharmacopoeia, and the FAO/WHO Joint Expert Committee on Food Additives (JECFA), all of which aim to protect the consumer of processed foods containing additives, and thus ensusre the safety of gum arabic from toxicological hazards. To achieve this end, gum arabic must conform to certain chemical specifications, and these must be adhered to, by both the producers and the processing enterprises. Among these requirements are that the gum arabic has to have a specific optical rotation of -26 to -34 degrees and nitrogen content of 0.24 - 0.41% (Anderson et al., 1990, 1991). These characteristics are met only by

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gum arabic from *A. senegal* (L.) Willd. var. *senegal* and not by gum talha from *Acacia seyal.* The Kenyan gum faces major problems relating to quality in the world market. According to a private sector player, Kenya's gum arabic obtained from *Acacia senegal* variety *kerensis* is not able to attract premium prices because of problems relating to inherent high viscosity. Some studies have shown differences between Kenyan gum arabic and gum from other countries such as the Sudan and Nigeria in terms of specific rotation, nitrogen and viscosity. These differences may have evolved as a result of the differences in edaphic conditions and climatic factors. In addition, quality problems (as a function of site and location of the tree) may also contribute towards the quality of gum (Chikamai and Odera, 2002)

The overall objective of this study was to establish the effect of chemical properties of soils on quality of gum arabic obtained from the natural stands of *A. senegal* (L.) Willd. var. *kerensis* Schweinf. trees. The specific objectives were to identify the natural stands of *Acacia senegal* variety *kerensis* and to collect soil and gum samples for analysis of gum quality in Logologo, Laisamis, Merille and Sereolipi in Marsabit and Samburu districts.

MATERIALS AND METHODS

Study areas were Logologo, Seepi and Turung'ung in Koya location of Laisamis, Santait and Kisapatai in Merille, and Kauro, Nenyirao in Sereolipi. The criteria used to select the study sites were high populations of naturally occurring stands of *Acacia senegal* variety *kerensis* trees. The sites were surveyed, selected and marked using Geographical Positioning System (GPS). Twenty soil samples of 500g were collected randomly at depth of 0 - 25 cm in polythene bags and nine gum samples of 100 g collected in paper bags from the stems and branches of *Acacia senegal* trees in each site. The samples were packed and taken for further pre-treatment and analysis. pH, organic carbon, nitrogen and phosphorus in soil and gum samples were analyzed respectively according to methods of Anderson and Ingram (1993) and Okalebo et al. (2002). Analysis of variance (ANOVA) was used to analyse data on chemical properties of soils and gum arabic from the study sites.

RESULTS AND DISCUSSION

The results of chemical properties of soils and gum arabic are given in Table 1. The soil pH in Laisamis, Lo-gologo, Sereolipi and Merille (6.6, 6.7, 6.3 and 6.0) were higher ($P < 0.05$) than those of gum arabic (4.54, 4.51, 4.54 and 4.52) from each particular site, respectively.

The soils of Laisamis and Logologo were less acidic than those of Sereolipi and Merrile, which were more acidic (Table 1). pH of gum arabic was strongly acidic and varied significantly with soil pH in all the four sites. These pH values are similar to pH of gum arabic (4.5) from Kargi and different from those of Isiolo and Ngurunit (4.4 and 4.3) given by Chikamai and Banks (1993). The pH values (4.50 - 4.54) in gum arabic from Laisamis, Logologo Sereolipi and Merrile were within the range of international specifications (pH: 4.2 - 4.8) FAO (1996,1999).

Soil organic carbon in Logologo and Laisamis (1.4 and 0.7 %) were significantly higher ($p < 0.05$) than those of Merrile and Sereolipi (0.3 and 0.2%), respectively. There were no significant difference ($p > 0.05$) in soil carbon from each other in Merrile and Sereolipi. The levels of soil carbon in Logologo and Laisamis were ascribed to soil pH (6.7 and 6.6) which influences the activity of micro-organisms in soil to increase uptake of carbon (H_2CO_3) by the tree leaves to form carbohydrates through the process of photosynthesis. Carbohydrates were transferred to stems and branches, which produced gum exudates with high carbon content. Soil organic carbon in Logologo and Laisamis (1.4 and 0.7%) were significantly higher ($p < 0.05$) than the carbon content in gum arabic (0.07 and 0.06) from the respective sites. The carbon content in soils of Merrile and Sereolipi (0.3 and 0.2%) were also significantly higher ($p < 0.05$) than those of gum arabic (0.15 and 0.03%) from same sites (Table 1). The carbon in gum arabic of Merrile (0.15%) was significantly higher than those of gum arabic found in Logologo, Laisamis and Sereolipi (0.073, 0.055 and 0.027%) respectively.

The levels of soil nitrogen in Logologo and Laisamis (0.8 and 0.4%) were significantly higher than those of Merrile and Sereolipi (0.3 and 0.3%), respectively (Table 1). Nitrogen content in the soils of Merrile and Sereolipi (0.3 and 0.3%) was significantly higher ($p < 0.05$) than those of gum arabic (0. 31 and 0.23%) found in each respective site. The levels of nitrogen in gum arabic from *Acacia senegal* variety *kerensis* in Sereolipi, Merrile, Laisamis and Logologo (0.31, 0.32 and 0.32%) were similar to nitrogen contents in gum arabic (0.28% - 0.34%) from *Acacia senegal* variety *kerensis* and *Acacia senegal* variety *senegal* in Marigat, Baringo District (Lelon, 2008). These results are different from the work by Chikamai and Banks (1993) on levels of nitrogen in gum arabic from *Acacia senegal* variety *kerensis* found in Kargi, Isiolo and Ngurunit (0.5, 0.4 and 0.43%). Nitrogen content in gum arabic from Laisamis, Logologo and Merrile (0.31, 0.32 and 0.32%) were within the range of international specifications (Phillips and Williams, 2001). Nitrogen content in gum arabic from Sereolipi (0.23%) fell outside the specifications (0.24 - 0.41%) (FAO, 1996); (Osman et al. 1993a, b).

The level of soil phosphorus in Laisamis (21.3 ppm) was significantly higher ($p < 0.05$) than those of Logologo, Sereolipi and Merille were (4.2, 6.4 and 4.5 ppm), respectively. This was attributed to soil pH (6.0 and 6.3) a dominant factor affecting the availability of phosphorus. Phosphorus becomes more available the lower the pH, since the solubility of phosphorus is highly dependent upon soil pH (Woolhouse, 1983). Phosphorus levels in gums from Sereolipi and Merrile (700.2 and 705.2 ppm) were significantly higher than those of Laisamis and Logologo (412.2 and 412.2 ppm), respectively. The levels of phosphorus in gums (700.2, 705.2, 412.2 and 412.2 ppm) were very high compared with those of soil phos-

Table 1. Chemical properties of soils and gum arabic in study sites.

Sites	Soil chemical properties				Chemical properties of gum arabic			
	pH	Organic carbon (%)	Nitrogen (%)	Phosphorus (ppm)	pH	Organic carbon (%)	Nitrogen (%)	Phosphorus (ppm)
Sereolipi	6.3	0.2	0.3	21.3	4.54	0.03	0.23	700.2
Merrile	6.0	0.3	0.3	6.4	4.52	0.15	0.31	705.2
Laisamis	6.6	0.7	0.4	4.5	4.50	0.06	0.32	412.2
Logologo	6.7	1.4	0.8	4.2	4.51	0.07	0.32	412.2

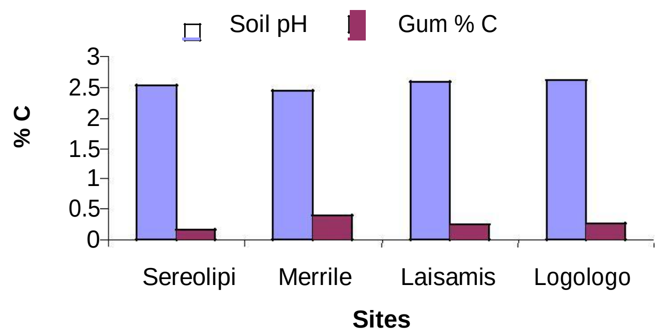

Figure 1. Comparison of Soil pH with % Carbon in Gum arabic in Sites.

phorus (21.3, 6.4, 4.5 and 4.2 ppm), respectively in all the sites (Table 1).

Effect of chemical properties of soils on gum arabic quality

Comparison of soil pH with percent carbon in gum arabic is given in Figure 1. Soil pH in Logologo Merrile, Laisamis and Sereolipi was not significantly different ($p > 0.05$) while percent carbon in gum arabic was significantly higher ($p < 0.05$) in Merrile than those of Sereolipi, Laisamis and Logologo (Figure 1).

The soil pH had effect on the level of soil organic carbon in the soils of Laisamis and Logologo which had direct relation to level of carbon in gum arabic obtained from the natural stands of *A. senegal* variety *kerensis.* In addition, increase in soil organic carbon resulted in low level of carbon in gums. In Merrile, soil pH influenced the level of carbon in gum arabic as shown in Figure 1.

Soil nitrogen had direct effect on the amount of nitrogen in gum arabic obtained from the natural stands of *A. senegal* in Merrile, Laisamis and Logologo which had direct relation to level of nitrogen. However, the impact of soil nitrogen was more pronounced in Merrile than in Laisamis and Logologo. In Sereolipi, soil nitrogen had no direct impact on the amount of nitrogen in gum arabic; this may be attributed to high level of soil phosphorus, which probably influences strong acidic nature of gum arabic (4.54) as shown in Table 1. In addition, increase in soil organic carbon resulted in high level of nitrogen in gum arabic obtained from the natural stands of *A. senegal* in Merrile, Laisamis and Logologo.

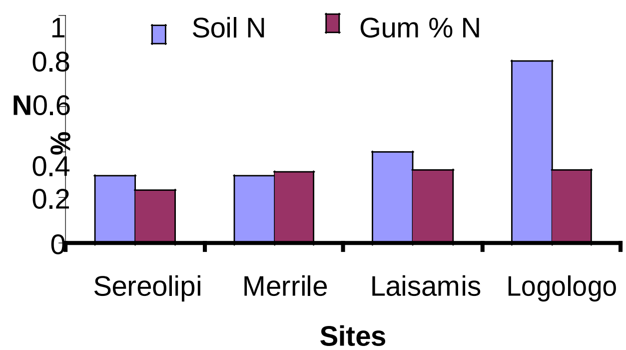

Figure 2. Comparison of Soil N with % Nitrogen in Gum arabic in Sites.

Comparison of soil nitrogen with percent nitrogen in gum arabic is given in Figure 2. Soil nitrogen in Logologo was significantly higher ($p < 0.05$) than those of Merrile, Laisamis and Sereolipi, while percent nitrogen in gum arabic was not significantly different in all the sites (Figure 2).

The levels of soil nitrogen in Merrile, Laisamis and Logologo were correlated ($p > 0.05$) to the nitrogen content (0.31 - 0.32%) in gum arabic, respectively, while soil N (0.3%) in Sereolipi was not significantly correlated to the nitrogen content (0.23%) in gum arabic harvested from natural stands of *A. senegal* variety *kerensis*(Figure 2). Nitrogen content in gum arabic from Merrile, Laisamis

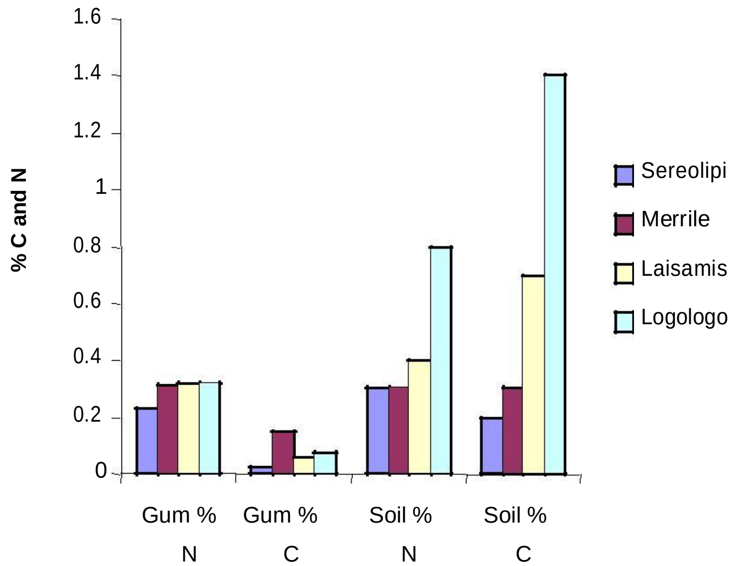

Figure 3. Comparison of Gum N with % Soil Nitrogen in the study sites

and Logologo were similar to those of international standards (0.24 - 0.41%) (Anderson et al., 1990, 1991; Biswas et al. 2000; Buffo et al., 2001).

Soil carbon and soil nitrogen in Logologo and Laisamis were significantly higher ($P< 0.05$) than those of Merille and Seereolipi (Figure 3). Logologo and Laisamis had similar trend in soil carbon, soil nitrogen and gum nitrogen, while Merille and Seereolipi varied in soil carbon, soil nitrogen, gum carbon and gum nitrogen (Figure 3).

Conclusions and Recommendations

The soil characteristics are major factors that influence the gum quality and production, particularly soil reaction (soil pH), organic carbon, nitrogen and phosphorus.

Nitrogen content in gum arabic from Merrile, Laisamis and Logologo were similar to those of international standards (0.24 - 0.41%).

Gums from the natural stands of *Acacia senegal* variety *kerensis* in Merrile, Laisamis, Logologo and Marigat, Baringo district can be mixed because of similar levels of nitrogen.

The pH of gum arabic from the natural stands of *Acacia senegal* variety *kerensis* in Sereolipi, Merrile, Laisamis and Logologo were 4.54, 4.5, 4.51 and 4.52 similar to the required international standards (pH: 4.2 - 4.8).

Further research is required to determine factors influencing the inherent high viscosity, nitrogen and specific rotation in relation to soil characteristics and varieties.

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