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Full Length Research Paper

Assessment of physical properties of gum arabic from *Acacia senegal* varieties in Baringo District, Kenya

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A study was conducted to assess the physical properties of gum arabic obtained from two *Acacia senegal* varieties (var.*senegal* and var.*kerensis*). in Marigat division, Baringo district. Gum arabic samples from the experimental sites at Solit, Kapkun, Kimorok and Maoi were collected, dried and analysed to establish their physical characteristics. Moisture content in gum arabic obtained from variety *kerensis* in Kimorok and Maoi (17.5 ± 1.00 and 15.4 ± 0.50%) were significantly higher ($P < 0.05$) than those of variety *senegal* in Solit and Kapkun (15.0 ± 0.50 and 14.9 ± 1.80%), while internal energy (33.4 and 33.76%) were not significantly different ($P > 0.05$) from those of variety *senegal* found in Kapkun and Solit (33.0 and 32.96%), respectively. Ash content in gum arabic from variety *senegal* in Solit and Kapkun (2.94 and 3.16%) was higher ($P < 0.05$) than those of variety *kerensis* found in Kimorok and Maoi (2.88 and 2.72%). In Kapkun, volatile matter in gum arabic from variety *senegal* (64.2%) was higher ($P < 0.05$) than the quantities of variety *kerensis* found in Kimorok, Solit and Maoi (63.8, 63.7 and 63.6%), respectively. Moisture content in gum arabic from variety *senegal* in Solit and Kapkun (15.0 ± 0.40 and 14.9 ± 1.80%) fell within international specifications (13 to 15%), while variety *kerensis* in Kimorok and Maoi (17.5 and 15.4%) fell outside the specifications. Moisture, ash and volatile matter contents in gum arabic from *A. senegal* variety *senegal* were 14.9, 3.16 and 64.24%, while *A. senegal* variety *kerensis* had 15.2, 2.88 and 63.8%, respectively. Moisture content in gum arabic from *A. senegal* variety *senegal* fell within international specifications while *A. senegal* variety *kerensis* fell outside the specifications. Ash, volatile matter and internal energy contents in gum arabic from *A. senegal* variety *kerensis* and variety *senegal* fell within the specifications. The gum arabic from *A. senegal* variety *senegal* in Solit and Kapkun was of better quality than that of *A. senegal* variety *kerensis* in Kimorok and Maoi.

Key words: Study sites, *Acacia senegal* varieties, physical properties, gum quality.

INTRODUCTION

Gum Arabic is dried exudates obtained from stems and branches of *Acacia senegal* trees which are cultivated in the Sudan as a cash crop in agroforestry systems (Duke, 1981). The international specifications used to assess the quality of gum arabic in the world market are based on the Sudan gum obtained from *A. senegal variety senegal* (Beshai, 1984; Larson and Bromley, 1991; Macrae and Merlin, 2002). The international specifications of quality parameters of gum arabic are given in Table 1.

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Physical properties of gum arabic

The physical properties of gum arabic, established as quality parameters include moisture, total ash, volatile matter and internal energy. Gum arabic is a natural product complex mixture of hydrophilic carbohydrate and hydrophobic protein components (FAO, 1990). Hydrophobic protein component functions as an emulsifier which adsorbs onto surface of oil droplets while hydrophilic carbohydrate component inhibits flocculation and coalescence of molecules through electrostatic and steric repulsions in food additives (Anderson and Weiping, 1990).

Table 1. International specifications of quality parameters of gum arabic*.

Property	Range		
Moisture content (%)	13 -	15	
Ash content (%)	2 -	4	
Internal energy (%)	30 -	39	
Volatile matter (%)	51 -	65	
Optical rotation (degrees)	-26 -	-34	
Nitrogen content (%)	0.26 -	0.39	
Cationic composition of total ash (550°C)			
Copper (ppm)	**Iron (ppm)**	**Manganese (ppm)**	**Zinc (ppm)**
52 - 66	730 - 2490	69 - 117	45 - 111

Source of Gum arabic: Kordofan gum belt region, Sudan. Species: *A. senegal* var. *senegal* and its varieties.
*Ref: FAO (1990).

Moisture content facilitates the solubility of hydrophilic carbohydrates and hydrophobic proteins in gum arabic (Elmqvist, 2003). Total ash content is used to determine the critical levels of foreign matter, acid insoluble matter, salts of calcium, potassium and magnesium (Mocak et al., 1998). The cationic compositions of ash content are used to determine the specific levels of heavy metals in quality of gum arabic (FAO, 1990, 1996).

Volatile matter of gum arabic determines the characteristics and the degree of polymerization contained in sugar compositions (arabinose, galactose and rhamnose) which exhibits strong emulsifying properties functioning as binders and stabilisers in the making of cough syrups in pharmaceutical industry (Phillips and Williams, 2001; Philips et al., 2006). Internal energy of gum arabic is the actual energy required to produce the amount of carbon when the gum is heated to 500°C to release carbon dioxide gas. Optical rotation is used to determine the nature of sugars in gum arabic obtained from *A. senegal* variety *senegal*. The specifications state that the best quality of gum arabic must have negative optical rotation with the range of -26° to -34° (Table 1). Nitrogen content in gum arabic determines the number of amino acid compositions with the range of 0.26 to 0.39% (FAO, 1990).

Gum arabic is used as an emulsifier and stabilizer in the food and pharmaceutical industries (Osman et al., 1993a, b). Other industrial products that use technical grades of gum arabic include adhesives, textiles, printing, lithography, paints, paper sizing and pottery glazing (Idris et al., 1998). Gum arabic is produced from natural stands of *A. senegal* varieties in arid and semi-arid lands (ASAL) ecosystem of northern Kenya (Chikamai and Gachathi, 1994; Chikamai, 1997). Gum arabic is collected during the dry seasons by herdsmen and women groups (pastoralists) from differ-rent botanical sources. The harvested gums are mixed and sold to middle businessmen in local trading centres who export without standard quality control to world market (Chikamai and Gachathi, 1994).

Kenya is currently a new supplier of gum arabic in the world market, but the country does not meet the competitiveness and adequate supply of the commodity to the market (FAO, 1995; 1997). Kenya's gum is not able to attract premium prices compared with the Sudan gum in the world market, because of problems relating to quality (FAO, 1990). The quality of gum arabic must conform to international specifications, which state the specific optical rotation and nitrogen content (-26° to -34° and 0.26 - 0.39%). The quality parameters must be adhered to, by both the producers and the processing enterprises (Anderson et al., 1990, 1991). The main factors affecting quality of Kenyan gums are obtained from different botanical sources, poor tapping methods and harvesting period, edaphic conditions and climatic factors (Chikamai and Odera, 2002). In addition, gum quality problems (as a function of site and location of the tree) may be influenced by source of origin, climate, soils, season and age of the tree (Chikamai, 1993).

The quality of Kenyan gum has not been investigated adequately to allow its improvement. It is anticipated that the quality of gum arabic from regenerated natural stands of *A. senegal* in a particular locality may be influenced by differences from one variety to the other, variation in soil types and compositions, specific habitats, climate, altitude and social factors. The overall objective of this study was to evaluate the physical properties of gum arabic obtained from the natural stands of *A. senegal* varieties between and within sites and determine factors that may influence the quality of gum arabic production under the ASAL conditions of Marigat division, Baringo district.

MATERIALS AND METHODS

Study area

The study sites were Solit (ST), Kimorok (KK), Kapkun (KN) and

Table 2. Physical properties of gum arabic from the study sites (Lelon, 2008).

Sites	Variety	Moisture content (%)	Ash content (%)	Volatile matter (%)	Internal energy (%)
		Mean ± S.E	Mean± S. E.	Mean ± S. E.	Mean ± S. E.
Solit	*senegal*	15.00 ± 0.50	2.94 ± 0.20	63.72 ± 0.40	32.96 ± 0.30
Kapkun	*senegal*	14.90 ± 1.80	3.16 ± 0.20	64.24 ± 0.30	33.00 ± 0.30
Kimorok	*kerensis*	17.50 ± 1.00	2.88 ± 0.20	63.80 ± 0.20	33.40 ± 0.30
Maoi	*kerensis*	15.40 ± 0.40	2.72 ± 0.20	63.60 ± 0.50	33.76 ± 0.60

n = 5. S. E. = Standard error.

Maoi (MI), in Marigat division, Baringo district. Baringo district is situated in the Rift Valley province of Kenya and lies between latitudes 0°15´ and 1°45´ N and longitudes 35°30´ and 36°15´ E. The district has three main agro ecological zones: lowlands, medium highlands and the highlands (GOK, 1993). The lowlands comprise the northern plateau, Lake Baringo and Kerio Valley basins. This area is predominantly a lowland dry zone which covers about 46% arid and semi-arid lands (ASALs), with low and erratic rainfall < 500mm), high potential evaporation rates, high temperatures and poor soils (Sombroek et al., 1982). The only activities in Marigat division are livestock, sorghum and millet farming. Selection of study sites was based on survey of high stand density, occurrence and wide distribution of *A. senegal* and its varieties. The size of the plots in Solit and Kapkun with high stand of *A. senegal* var. *senegal* and other closely related species was 0.5 and 1.0 ha, while 0.8 and 1.0 ha for Kimorok and Maoi with high stand density of *A. senegal* var. *kerensis* and other closely related species (Lelon, 2008).

Gum arabic analysis

Ninety gum arabic samples of about 200 g were collected from the four sites during the dry seasons from the two varieties of *A. senegal*: *senegal* and *kerensis*. The samples were air dried for fourteen days and ground using a pestle and mortar for analysis of moisture content, ash, volatile matter and internal energy.

Methods of analysis of physical properties of gum arabic

Analysis of moisture and ash contents was determined using a clean dry crucible of known weight and oven dried at 105°C for 6 h. Moisture content was taken as percentage ratio of the change in weight to the original sample weight. The dry weight of ash was ignited at 550°C in a muffle furnace for one hour, contents removed, cooled in a desiccator for 30 min and weighed. The ash content was taken as the percentage loss in weight after ignition that of the original sample. Internal energy was obtained by placing a clean dry crucible of known weight in a muffle furnace and temperature raised to 550°C. The contents removed, cooled in a dessicator for 30 min and weighed and ignited at 850°C for two hours, then cooled in a dessicator for 30 min and weighed. Internal energy was determined as the percentage loss in weight after ignition of the original sample. Volatile matter was determined as percentage ratio of the change in weight to the original sample weight according to the methods of Anderson and Ingram (1993) and Okalebo et al. (2002).

Data analysis

Statistical analysis of data was carried out using SPSS for windows Release 8.0.0 (1997) and Microsoft Excel (2003) computer software. The statistical method used was Analysis of Variance (ANOVA) using Generalized Linear Models Procedure (GLM).

RESULTS AND DISCUSSION

Physical properties of gum arabic in the study sites

The physical properties of gum arabic from the four study sites are given in Table 2.

Moisture content

Moisture content in gum arabic obtained from variety *kerensis* in Kimorok and Maoi (17.5 ± 1.00 and 15.4 ± 0.50%) were higher ($P < 0.05$) than those of variety *senegal* in Solit and Kapkun (15.0 ± 0.50 and 14.9 ± 1.80%), respectively. Moisture content in gum arabic from variety *senegal* in Solit and Kapkun (15.0 ± 0.40% and 14.9 ± 1.80%) fell within international specifications (13 to 15%), while variety *kerensis* in Kimorok and Maoi (17.5 and 15.4%) fell outside the specifications (Table 1). Gum arabic from *A. senegal* variety *senegal* in Solit and Kapkun was of better quality than that of variety *kerensis* in Kimorok and Maoi (Anderson and Weiping, 1990).

Ash content

Ash content in gum arabic from variety *senegal* in Solit and Kapkun (2.94 and 3.16%) was higher ($P < 0.05$) than those of variety *kerensis* found in Kimorok and Maoi (2.88 and 2.72%), respectively (Table 2). Ash content in gum arabic from *A. senegal* varieties in the study sites fell within the international specifications (Table 1). The ash content of the Kenyan *A. senegal* varieties was better than that found in Uganda (4.5%) which falls outside the international specifications (Anderson and Weiping, 1991).

Volatile matter

In Kapkun, volatile matter in gum arabic from variety *senegal* (64.2%) was higher (P < 0.05) than the quantities of variety *kerensis* found in Kimorok, Solit and Maoi (63.8, 63.7 and 63.6%), respectively (Table 2). Volatile matter contents of the gum arabic from both varieties (64.2, 63.7, 63.8 and 63.6%) were within the international specifications range of 51 to 65% (Table 1).

Internal energy

Internal energy in gum arabic obtained from *A. senegal* variety *kerensis* in Maoi and Kimorok (33.76 and 33.4%), were not significantly different (P > 0.05) from those of variety *senegal* found in Kapkun and Solit (33.0 and 32.96%), respectively (Table 2). The internal energy in gum arabic from *A. senegal* varieties meets the international specifications (30 to 39%), FAO (1990) (Table 1).

Conclusion

Moisture content in gum arabic from *A. senegal* variety *senegal* fell within international specifications while *A. senegal* variety *kerensis* fell outside the specifications.

Ash, volatile matter and internal energy contents in gum arabic from *A. senegal* varieties *kerensis* and *senegal* fell within the specifications.

The gum arabic from *A. senegal* variety *senegal* in Solit and Kapkun was of better quality than that of *A. senegal* variety *kerensis* in Kimorok and Maoi.

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REFERENCES

Anderson DMW, Brown DDM, Morrison NA, Wang W (1990). Specifications for gum arabic (*Acacia senegal*) analytical data for samples collected between 1904 and 1989. Food. Addit. Contam. 7(3): 303-321.

Anderson DMW, Millar JRA, Wang W (1991). Gum arabic *(Acacia senegal):* unambiguous identification by 13C-NMR spectography as an adjunct to the Revised JECFA Specification and the application of 13C-NMR spectra for regulatory legislative purposes. Food. Addit. Contam. 8(4): 405-421.

Anderson JM, Ingram JSI (1993). Tropical soil biology and fertility: A handbook of methods. CAB International, Wallingford, UK.

Beshai AA (1984). The economics of a primary commodity: gum arabic. Oxf. Bull. Econ. Stat. 46(4): 371-381.

Chikamai BN (1997). “Production, Markets and quality control of Gum arabic in Africa: Findings and Recommendation for FAO Project. In J. O. Mugah, B.N. Chikamai and E. Casadei (eds.)” Conservation, Management and Utilization of Plant Gums, resins and essential oils.” Proceedings of a Regional conference for Africa held in Nairobi, Kenya.

Chikamai BN, Banks WB (1993). “Gum arabic from *Acacia senegal* (L) Wild. in Kenya. Food Hdrocolloids 7(6): 521-534.

Chikamai BN, Gachathi N (1994). “Gum and Resin Resources in Isiolo District, Kenya. Ethnobotanical and Reconnaissance survey”. E. Afr. For. J. 59(4): 345-351.

Chikamai BN, Odera JA (Eds.) (2002). Commercial Plant Gums and Gum Resins in Kenya. Sources of Alternative Livelihood and Economic Development in the Drylands of Kenya. Executive Printers. Nairobi-Kenya.

Duke JA (1981). Handbook of Legumes of World Economic Importance. Plenum Press. NewYork.

Elmqvist B (2003). “The vulnerability of traditional agroforestry systems: a comparison of the gum arabic livelihood strategy before the 1984 drought to that of the present in Kordofan-Sudan”. Paper presented on Environment, Place and Sustainable Natural Resource Management Conference. Uppsala, Sweden 2003.

FAO (1995). Gums, resins and latexes of plant origin. Non wood forest products Vol. 6.

FAO (1996). A Review of Production, Markets and Quality Control of Gum Arabic in Africa. FAO, ROME.

FAO (1997). Food and Nutrition Paper No. 52: 5.

FAO, Rome (1990). Food and Nutrition paper 49: 23.

Government of Kenya (GOK) (1993). National Development Plan, Government Printers, Nairobi.

Idris OHM, Williams PA, Phillips GO (1998). Characterization of gum from Acacia senegal trees of different age and location using multidetection gel permeation chromatography. Food Hydrocolloids 12: 379-388.

Larson BA, Bromley DW (1991). “Natural resource prices, export policies and deforestation: the case of Sudan”. World Dev. 19(10): 1289-1297.

Lelon JK (2008). Uptake of Micronutrients by *Acacia senegal* varieties and it Possible Effect on Gum arabic quality. Ph D Thesis, University of Nairobi.

Macrae J, Merlin G (2002). “The prospects and constraints of development of gum arabic in Sub-Saharan Africa”. Washington, D.C., World Bank.

Mocak J, Jurasek P, Phillips GO, Vargas, Casadei E, Chikamai BN (1998). The classification of natural gums. X. Chemometric characterization of exudate gums that conform to the revised specification of the gum arabic for food use, and the identification of adulterants. Food Hydrocolloids 12: 141-150.

Okalebo JR, Gathua KW, Woomer PL (2002). Laboratory methods of soil and plant analysis: A working manual. Second Edition. TSBF-CIAT and SACRED Africa, Nairobi, Kenya.

Osman ME, Menzies AR, Williams PA, Phillips GO, Baldwin TC (1993a). The molecular characterisation of the polysaccharide gum from Acacia senegal. Carbohydr. Res. 246: 303-318.

Osman ME, Williams PA, Menzies AR, Phillips GO (1993b). Characterization of commercial samples of gum arabic. J. Agric. Food Chem. 41: 71-77.

Phillips GO, Williams PA (2001). Tree exudate gums: natural and versatile food additives and ingredients. Food Ingred. Anal. Int. 23: 26, 28.

Sombroek WG, Brawn HMH, Van der Pouw BJA. (1982). "The exploratory soil Map and agro-climatic zone map of Kenya". Exploratory Soil Survey Report E1. Kenya Soil Survey, Nairobi.