

Full Length Research Paper

Nutritional contents of *Balanites aegyptiaca* and its contribution to human diet

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Wild edible plants are used as food and energy sources. However, their uses are not as the potential inherent in the resources. *Balanites aegyptiaca* is a multipurpose species in semiarid areas including Ethiopia. Hence, quantitative nutrition study in specific habitat is essential for sustainable use of the species. Composite fruits sample of *B. aegyptiaca* was collected from six areas of east Shewa, Ethiopia for nutrient analysis following standard laboratory procedure. The results reveal that the fruits are rich in P, Ca, Fe, Zn, Cu, Na, K, Mg and Mn. The nutritional content varied ($P < 0.05$) across land uses. Mean calculated energy value of lipids ranged from 0.09-0.27 kcal 4.2-7.68 for *B. aegyptiaca* and the total energy from carbohydrate was 342.2-354.24 kcal. Therefore, the fruit of *B. aegyptiaca* is promising in terms of nutrient content to human's diet diversification. It is a valuable species particularly during dry season for coping and adapting to climate variability/change. In spite of the promising potential, the nutritional contribution of this species to the people's diet remained underutilized. Therefore, the utilization of *B. aegyptiaca* is justified to be considered for integration in dryland agrobiodiversity systems and nutrition research to enhance the contribution to the diet of people and enhance its sustainable utilization.

Key words: Food security, nutrition, diet.

INTRODUCTION

Consumption of wild edible plants (WEPs) was practiced for ages. Nebel et al. (2006) explained that there has been renewed interest worldwide in consumption of wild food plants. Despite the increased reliance by agricultural societies' on conventional crop plants, the tradition of eating wild plants has not completely disappeared; their nutritional role and health benefits are

being reported in many studies (Pardo-de-Santayana et al., 2007). Wild food plants are used as a source of food energy, sources of vitamins and minerals. They were important as dietary supplements, providing trace elements, vitamins and minerals (Gillman, 2008, Debela et al., 2011).

In spite of many studies on WEPs focused on the

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functions within ecology and ecosystems there are few research works that compared the food plants of various communities (Ladio et al., 2006). Some research works have compared medicinal floras and other useful plants (Pieroni and Quave, 2005). Such comparative studies therefore contribute to the understanding of why edible species are widely consumed or given little attention and provide insights into food and nutrition security potential of different communities.

Food and nutritional security are key issues for human wellbeing while WEPs are underutilized in many countries including in Ethiopia. Fentahun and Hager (2009) have reported that wild edible fruits contribute to nutrition and health security of rural people as they contain proteins, vitamins and minerals. In the first phase of this work which is already published in Debela et al. (2011) and others, the proximate (carbohydrate, lipids and total minerals) were addressed. However, the information on the fruits nutritional quality of the species is not exhaustively documented. The specific minerals and vitamins contents were not determined in this study. Therefore, these studies curve this research gap through further analysis of the nutrient composition macro and micronutrients of *Balanites aegyptiaca*. It also indicates future line of research on the contribution of *B. aegyptiaca* to nutrition and food security of the semiarid people. Therefore, this study was aimed at analysing the nutritional content of *B. aegyptiaca* and implications to food and nutrition of people in semiarid areas.

MATERIALS AND METHODS

The study area

The study was conducted in 'Fantalle' and 'Boosat' districts, in East Shewa Zone of Oromia National Regional State, Ethiopia. East Shewa is located between 7°12'-9°14'N latitudes and 38°57'-39°32'E longitudes in the northern part of the Great East African Rift Valley.

Collection and preparation of fruit sample for laboratory analysis

Frequency distribution and density of *B. aegyptiaca* in the local vegetation was systematically determined by total count of shrubs and trees from 20 x 20 m of 66 plots (33 from each district) laid at 200 m interval on the 5 km line transects.

Before undertaking laboratory nutrient analysis, fruit samples of *B. aegyptiaca* were identified through focus group discussion (FGD), interview and field observations as described in Martin (1995) and Cotton (1996) by repeated field visits between 2009 and 2010. Composite fruit samples of the species were collected in a sample bag from Fantalle (Galcha, Qobo and Dheebiti villages) and Boosat (TriiBiretti, DigaluTiyo and Xadacha villages) districts for nutrient analysis.

Minerals, vitamins A and C and tannin analysis

The mineral elements comprising sodium, calcium, potassium, magnesium, iron, zinc and phosphorus were determined according to the method of Shahidi et al. (1999), Sundriyal and Sundriyal

(2004), AOAC (1990) and Nahapetian and Bassiri (1975). Two gram of each of the processed samples was weighed and subjected to dry ashing in a well-cleaned porcelain crucible at 550°C in a muffle furnace.

The resultant ash was dissolved in 5.0 ml of HNO₃/HCL/H₂O (1:2:3) and heated gently on a hot plate until brown fumes disappeared. To the remaining material in each crucible, 5 ml of de-ionized water was added and heated until a colourless solution was obtained. The mineral solution in each crucible was transferred into a 100 ml volumetric flask by filtration through Whatman No.42 filter paper and the volume was made to the mark with de-ionized water. This solution was used for elemental analysis by atomic absorption. A 10 cm long cell was used and concentration of each element in the sample was calculated on percentage of dry matter, i.e. mg/100g sample. Phosphorus content of the digest was determined colorimetrically according to the method described by Nahapetian and Bassiri (1975).

For tannin determination samples were dried at a maximum of 60°C immediately after collection to minimize any chemical changes and extracted with 50%v/v acetone. Determination was by a modification of the vanillin method of Ranganna (1977) and Broadhurst and Jones (1978), which utilizes the formation of coloured complexes between vanillin and condensed tannins and Catechin was used for the standard, and results were expressed as catechin-equivalents.

Determination of vitamin A was carried out by spectrophotometer following Davies (1976) and (AOAC, 1990). Ascorbic acid (vitamin C) was determined by redox titration using iodate (I₃) following (Pearson, 1976) and Helmenstine (2007).

Determination of percentage titrable acidity and total soluble sugar (TSS)

Titrable acidity was determined by titration using 0.1 N NaOH. Titration was done by adding 0.1 N NaOH from a burette to the Erlenmeyer flask containing 10 ml of fruit solution prepared in measuring while swirling until the solution just starts to change colour to pink/purple (slightly pink). The amount of NaOH added to the flask was recorded immediately at this end point. Multiplied the volume of sodium hydroxide (volume of titre) added by acid conversion factor of the fruit acid to get the value of the acid (in grams per 100 ml); that is, TSS of fruit indicator used is 2-3 drops of phenolphthalein indicators from burette filled, along with phenolphthalein indicators (AOAC, 1990, OECD, 2005). Soluble solids (TSS) content was determined directly in the fruit juice, using a portable/handle held refractometer (Pocket PAL-1, UK) at room temperature in degree Brix (°Brix) following (Khemiss et al., 2005; Franco et al., 2009). Degrees Brix (°Bx) is a unit representative of the sugar content of an aqueous solution.

Determination of energy value

Energy of the WEPs fruits was calculated in kilocalories (kcal) multiplying by energy factor composition (4, 4 and 9) of percentage proteins, fats and carbohydrates respectively as used in FAO (1968, FAO, 2011), USDA (1999) and Asibey-Berko and Tayie (1999). The conversion factors are for physiological energy, which is the energy value remaining after losses due to digestion and metabolism and deducted from gross energy (USDA, 1999) where one kcal equals 4.184 kJ. Organic carbon (O.C) in the fruit was obtained by subtracting total ash from 100 (Adams et al., 1951).

Data analysis

Statistical analysis for nutritional content of *B. aegyptiaca* was done

through analysis of variance and means were separated by LSD at $P < 0.05$ using GenStat (VSN International, 2011). Organic carbon (O.C) in the fruit of threatened WEP was calculated using formula $\% \text{ O.C} = (\% \text{ VS}/1.8) \times 100$, where, $\% \text{ VS} = (100 - \% \text{ Ash})$ following Adams et al. (1951). TSS obtained directly from Refractometer was expressed in °Brix. Titrable acidity was calculated by:

$$\text{TA (\%)} = \frac{\text{mL of NaOH (Titre)} \times 0.1 \text{N NaOH} \times \text{acid meq. factor}}{\text{mL of juice titrated}} \times 100$$

and was expressed as g malic acid 100 g⁻¹ fresh weight (F.W.) (AOAC, 1990; Franco et al., 2009).

RESULTS AND DISCUSSION

Abundance and distribution of *B. aegyptiaca*

The present study indicated that, the average % relative frequency is 24.24 and Av% relative density was 0.96 in settled farmers land use and av % frequency was 33.33 and Av % relative density was 2.27 in transhumance land use for *B. aegyptiaca*. Direct repeated field visit and observation in the study areas revealed that the natural forest is more degraded in settled farmers area due to charcoal and firewood production, expansion of agriculture and settlements in settled farmers areas. Commercial fuel wood (charcoal and firewood) production was observed. *B. aegyptiaca* has declined in natural forest due to overharvesting. Cutting down local vegetation for building of houses for the increased settlement in the area has affected *B. aegyptiaca*. As reported by informants during field observations, overgrazing/browsing by camels and goats is a serious threat to the vegetation of the area including *B. aegyptiaca*.

Local consumption of WEPs as food was not regarded as a threat to the survival of WEP species unless when demand becomes higher than sustainable harvest in the future. Gamado-Dalle et al. (2005) and Asfaw (2009) reported that local people maintain species which are useful to their livelihood at farm borders, live fences and sacred areas.

Nutritional potential of *B. aegyptiaca*

The results indicate the existence of variations of nutrient and energy from *B. aegyptiaca* from different study sites. This can be attributed to environmental factors such as soil, temperature and rainfall. In spite of the variations within and between land uses, the result indicated that *B. aegyptiaca* has significant amount of nutrients and energy to supplement household nutrition and a good income source if properly valued.

Besides direct nutritional contributions through carbohydrates, lipids, proteins, minerals and energy; the diversity of wild fruits by itself is a source of variety and taste in the local meals of rural communities including Ethiopia. Earlier studies made by FAO (1995) on non-

timber forest products focusing on nutrition, and in India on nutrient composition of specific plants (Parvathi and Kumar, 2002) have reached similar conclusion. In east Shewa, the nutritional contribution of *B. aegyptiaca* and value are hardly recognized in the formal production system as it is overshadowed by the values of conventional food crops and charismatic species such as *Eragrostis tef*, *Triticum aestivum*, *Sorghum bicolor*, *Zea mays* and others.

Comparison of the results of the present study with the nutrient content of some cultivated fruits noted by Srivastava and Kumar (1998) revealed that they are superior in protein content to banana (1.2 and 0.3%), guava (0.9 and 0.3%) respectively; mango (0.6 and 0.4%, respectively) and papaya (0.6 and 0.1%) respectively.

Test also contributes to the nutritional quality of a fruit. In this regard, the relatively high tannin content of *B. aegyptiaca* may be a point of argument to fully recommend the fruit for common use for human diet. Chapagain and Wiesman (2007) also reported nine compounds from *B. aegyptiaca* of which six of them were saponins with molecular masses of 1196, 1064, 1210, 1224, 1078 and 1046 Da.

The same report revealed that the compound of mass 1210 Da being the main saponin (ca. 36%). Saponins with masses of 1224 and 1046 Da have not been previously reported in *B. aegyptiaca*. Chapagain and Wiesman (2007) also reported that in all saponins, diosgenin was found to be the sole aglycone. Though people use *B. aegyptiaca* fruits, the controversial issues of saponins and consequent bitter test and the impact consumption pattern and nutritional quality is question not addressed by the present study.

Interaction effect of fruit of *B. aegyptiaca* and land use on mineral and tannin contents

The mineral and tannin contents of *B. aegyptiaca* significantly varied across land uses ($P < 0.05$) (Table 1). Phosphorus content is highest in *B. aegyptiaca* for sampled collected from transhumance land use. Sodium content was highest in *B. aegyptiaca* followed for samples collected from settled farming area (Table 1).

Interaction effect of land use on Vitamin A and C contents of *B. aegyptiaca* species

Vitamin C content of *B. aegyptiaca* was 50.30 and 50.90 on mg/ 100 g dry matter basis for SF and TH land uses respectively and not significantly varied ($P > 0.05$) across land uses. Vitamin A content (Beta carotene REs, Retinol Equivalents) for *B. aegyptiaca* was 233.70 and 266.33 for SF and TH land uses respectively which significantly varied between land uses ($P < 0.05$) with higher mean value from sample collected from transhumance land use systems.

Table 1. Interaction effects of fruit tree species with land use system on mineral and tannin contents of *B. aegyptiaca* in mg/100 g dry matter basis.

| Nutrient contents across land uses | Nutrient and tannin contents | | | | | | | | | |
|------------------------------------|------------------------------|--------|--------|---------|---------|--------|---------|--------|---------|---------|
| | P | Ca | Fe | Zn | Cu | Na | K | Mg | Mn | CT |
| SF* <i>B. aegyptiaca</i> | 102.625 | 74.550 | 39.700 | 0.5500 | 0.0950 | 22.100 | 1990.30 | 87.070 | 0.8200 | 1219.88 |
| TH* <i>B. aegyptiaca</i> | 103.55 | 76.650 | 40.360 | 0.3150 | 0.1002 | 20.100 | 1992.50 | 87.635 | 0.7850 | 1222.10 |
| LSD (5%) | 0.1806 | 0.7824 | 0.1594 | 0.8667 | 0.03726 | 0.1816 | 1.589 | 0.6627 | 0.05051 | 2.07 |
| s.e.d | 0.0783 | 0.3393 | 0.0691 | 0.03758 | 0.00808 | 0.0787 | 0.689 | 0.2874 | 0.02190 | 0.898 |
| Sig* | 0.014 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | 0.005 | <0.001 | 0.008 |

SF=settled farmers; TH=transhumant land uses; Means with the same letter are not significantly different ,P=Phosphorus; Ca=Calcium; Fe=Iron,Zn=Zink,Cu=Copper; Na=Sodium; K=potassium; Mg=magnesium; Mn=manganese; CT=condensed tannin,*= significant at 0.05 level, s.e.d = standard error of the differences.

Percentage titrable acidity and total soluble solids in composite fruits pulp samples

Analysis of variance between locations revealed that in % TTA (1.37) and TSS (4.35) and TSS/ %TTA is not significant ($P>0.05$). However, the mean values %TTA and TSS °Brix related that the fruits *B. aegyptiaca* have relatively high characteristics of sourness combined with a high degree of sweetness taste. By extrapolation, the total soluble solid was lower. The TSS/%TTA ratio (3.18) also indicated the fruit can be consumed by humans.

Comparison of energy content of *B. aegyptiaca* fruits

The result of the present study indicated that mean calculated energy value of lipids ranged from *B. aegyptiaca* from 0.09-0.27 kcal to 4.2-7.68 for *B. aegyptiaca*. Energy for total carbohydrate was 342.2-354.24 kcal for *B. Aegyptiaca* (FAO, 1968; 2011).

Conclusions

The fruit of *B. aegyptiaca* is promising in terms of nutrient content to humans and livestock. The results of the nutrient analyses showed that *B. aegyptiaca* fruits can be important indigenous sources of nutrients to supplement other major food sources. This is a valuable plant particularly during dry season for coping and adapting to climate variability/change. Though it has good potential, the nutritional contribution of this species to the human diets is not sufficiently utilized. On top of this, there is a need of more research on the identification of the bitter components and their effects on human nutritional utilization and quality. Hence, *B. aegyptiaca* need be considered for integration in dryland production system such as agrobiodiversity systems to improve the livelihoods of people and promote its sustainable utilization by improving nutritional quality through more research.

Conflict of interests

The authors did not declare any conflict of interest.

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REFERENCES

- Adams RC, MacLean FS, Dixon JK, Bennett FM, Martin GI, Lough RC (1951). The utilization of organic wastes in N.Z.: Second interim report of the inter-departmental committee. New Zealand Eng. 15:396-424.
- AOAC (1990). Official methods of analysis, 14th Edition, Association of Official Analytical Chemists, Washington DC.
- Asfaw Z (2009). The Future of Wild Food Plants in Southern Ethiopia Ecosystem Conservation Coupled With Management of the Roles of Key Social Groups. In: International Symposium on Underutilized Plants for Food Security, Nutrition, Income and Sustainable Development International Society for Horticultural Science-ISHS, January 2009, pp. 86-87.
- Asibey-Berko E, Tayie FAK (1999). Proximate analysis of some underutilized Ghanaian Vegetables. Ghana J. Sci. 39: 91-92.
- Broadhurst RB, Jones WT (1978). Analysis of condensed tannins using acidified vanillin. J. Sci. Food Agric. 29:788 -794.
- Chapagain BP, Wiesman Z (2007). Determination of saponins in the kernel cake of *Balanites aegyptiaca*. Phytochem. Anal. 18(4): 354-362.
- Cotton CM (1996). Ethnobotany: Principles and applications. Chichester, New York John Wiley and Sons Ltd.
- Davies BH (197). Analytical Methods: Carotenoids. In: Chemistry and Biochemistry of plants pigments. Godwin, T.W. (ed). Academic press, London, Vol. 4: 125-127.
- Debela HF, Njoka JT, Zemedu A, Nyangito MM (2011). Wild edible

- fruits of importance for human nutrition in semiarid parts of East Shewa Zone, Ethiopia: Associated Indigenous Knowledge and Implications to Food Security. *Pak. J. Nutr.* 10(1):40-50.
- FAO (1968). Food composition table for Use in Africa. Energy Factor, p. 226.
- FAO (1995). Non-wood forest products in nutrition. In: Non-Wood Forest Products for Sustainable Forestry, Yogyakarta, Indonesia, 17-27 January, 1995. Non-Wood Forest Products, Vol. 3. FAO, Food and Nutrition Division, Rome.
- FAO (2011). Calculation of the energy content of foods - energy conversion factors. <http://www.fao.org>. (Accessed March, 2011).
- Fentahun MT, Hager H (2009). exploiting locally available resources for food and nutritional security enhancement: wild fruits diversity, potential and state of exploitation in the Amahara Region of Ethiopia. *J. Food Sec.* 1:207-219.
- Franco MV, Fanco-Mora O, Lopez-Sandoval JA, Perez-Lopez DJ, Balbuena-Melgarejo A (2009). Characterization of wild plum (*Ximena americana* L. var. *americana*; Olacaceae) fruit growing at Tepexi de Rodríguez, Puebla, Mexico. *Genet. Resour. Crop Evol.* 56:719-727.
- Gemedo-Dalle T, Maass BL, Isselstein J (2005). Plant biodiversity and ethnobotany of Borana pastoralists in Southern Oromia, Ethiopia. *Econ. Bot.* 59(1):43-65.
- Gillman S (2008). The Cattail - Best of the Wild Edible Plants. Free Online Articles Directory. <http://www.articlesbase.com/camping-articles/the-cattail-best-of-the-wild-edible-plants-495731.html>
- Helmenstine AM (2007). Vitamin C Determination by Iodine Titration. doi:10.1016/j.foodchem.2007.02.037.
- Khemiss F, Ghoul-Mazgar S, Moshtaghi AA, Saidane D (2005). Study of the effect of aqueous extract of *Grewia tenax* fruit on iron absorption by everted gut sac. *J. Ethnopharmacol.* 103:90-98.
- Ladio A, Lozada M, Weigandt M (2006). Comparison of traditional wild plant knowledge between aboriginal communities inhabiting arid and forest environments in Patagonia, Argentina. *J. Arid Environ.* 2007:695-715.
- Martin GJ (1995). *Ethnobotany: a methods manual*. London, UK: Chapman and Hall.
- Nahapetian A, Bassir A (1975). Changes in concentration and interrelationships of phytate, P, Mg, Cu, Zn in wheat during maturation. *J. Agric. Food Chem.* 23:1179-1182.
- Nebel S, Pieroni A, Heinrich M (2006). Ta chòrta: Wild Edible Greens Used in the Graecanic area in Calabria, southern Italy. *Appetite* 47(3):333-342.
- OECD (2005). Guidance on Objective Tests to Determine Quality of Fruits and Vegetables and Dry and Dried Produce. Organization for Economic Co-Operation and Development. [Http://www.Ble.De/Nn_680006/Shareddocs/](http://www.Ble.De/Nn_680006/Shareddocs/)
- Pardo-de-Santayana M, Javier Tardío J, Blanco E, Carvalho AM, Juan José Lastra JJ, Miguel ES, Morales R (2007). Traditional knowledge of wild edible plants used in the northwest of the Iberian Peninsula (Spain and Portugal): a comparative study. *J. Ethnobiol. Ethnomed.* 3:27.
- Parvathi S, Kumar VJF (2002). Studies on chemical composition and utilization of the wild edible vegetable athalakkai (*Momordica tuberosa*). *Plant Foods Hum. Nutr.* 57 (3-4):215-222.
- Pearson D (1976). *The Chemical analysis of foods*, Seventh ed. London and New York, Pp, 575.
- Ranganna S (1977). *Manual of analysis of fruit and vegetables products*. New Delhi: Tata McGraw-Hill Publishing Company Limited, p. 634.
- Shahidi F, Chavan UD, Bal AK, Mckenzie DB (1999). Chemical Composition of Beach Pea (*Lathyrus Maritimus* L.) Plant parts. *Food Chem.* 64: 39-44.
- Sundriyal M, Sundriyal RC (2004). Wild Edible Plants of the Sikkim Himalaya: Values of Selected Species. *Econ. Bot.* 58(2):286-299.
- USDA (1999). US Department of Agriculture, Agricultural Research Service, USDA Nutrient Data Laboratory. USDA Nutrient Database for Standard Reference, Release 13.
- VSN International (2011). GenStat Discovery Edition 3, software for bioscience. VSN International Ltd. <http://www.vsn.co.uk/software/genstat-discovery/>