INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
IJPAES
Volume-4, Issue-2, April-June-2014
ISSN 2231-4490

Coden : IJPAES www.ijpaes.com

Received: 17th Feb-2014 *Revised: 20th March-2014* *Accepted: 25th March-2014*

Research article

POSTHARVEST HANDLING OF THE EDIBLE PARTS (LEAVES AND FRUITS) OF THE DESERT DATE (*BALANITESAEGYPTIACA)* A CASE STUDY IN THE JIRAPA AND NADOWLI DISTRICTS OF THE UPPER WEST REGION OF GHANA

[1]Ninfaa Dery Augustus, [2]Maalekuu B.K &[3]Akurugu Gordon K.

[1]Department of Ecological Agriculture, School of Applied Science and Arts, Bolgatanga Polytechnic, P.O. Box 767, Bolgatanga- Ghana
[2]Kwame Nkrumah University of Science and Technology, Department of Horticulture
[3]Food and Drugs Authority, P. O. Box 291, WA- Upper West Region, Ghana

ABSTRACT: The study was conducted in the Nadowli and Jirapa Districts of the Upper West Region of Ghana, with the objectives of documenting the uses of the desert date, determining the methods of harvesting the leaves and the fruits since the plant is very thorny, identifying the methods of processing and preserving the fruits and the leaves and determining the nutritional composition of the leaves and fruits.Cutting down and plucking the leaves and standing by tree and plucking leaves were the two major methods of harvesting the leaves while the fruits are allowed to fall and they pick them.The leaves and the dry fruits are edible, the leaves are eaten as vegetables in soup or added to a prepared meal called 'koose', the leaves are processed and preserved by boiling and drying while the fruits are dried and preserved or the coat is peeled off and soaked in water for a drink.The root is poisonous and used for fishing. The stem of the plant is used for fuel and can also be carved in to mortar and pestles.Nutritionally, the leaves contain 41.41% moisture, 17.06% protein 16.02% fibre, 30.92% carbohydrates and 231.02 Cal/100g of energy while the fruits contain 24.63% moisture, 3.85% protein, 8.72% fibre 59.53% carbohydrates and 277.02 Cal/100g of energy.The desert date plant grows in the wild and has various uses in the area, therefore the people should be encouraged to eat and cultivate it.

Keywords: Desert date, edible, fibre, leafy vegetables, nutrition, preserving, processing

INTRODUCTION

Balanitesaegyptiaca also known as Desert date in English, 'dattier du desert' in French, 'heglig' in Arabic, 'mjunju' in Swahili, 'tanni' in Fulfulde, 'adua' in Hausa and 'cungo' in Kanuri [6] is one of the most widely distributed trees in Africa. Although found almost everywhere in the continent, very high concentrations of the tree are most prevalent in sahel and sudan savanna zones of West Africa and semi-arid regions of East Africa [9]. Two accessions of the tree with fruit, nut and kernel shapes that corroborate the findings of Launert [8] are common in North Eastern Nigeria. The roots and bark of the desert date are pounded and dipped in rivers for fishing, the wood as yoke for draught animals and hand implements, while humans eat the leaves and flesh of the ripe fruit because they are very rich in carbohydrates and vitamins. The most important part of the *Balanitesaegyptiaca* tree is the nut, also called stone [9]. The nut is obtained after the removal of the flesh and pulp of the fruit and it contains a kernel with oil and protein contents ranging from 30–60% and 20–30% respectively. The oil is good for cooking as it has an acceptable scent and taste [6], and does not smoke excessively when heated [9]. The kernel meal remaining after oil extraction can be used as livestock feed [2]. Processing of *Balanitesaegyptiaca* fruit involves soaking it in cold water for three days or hot water for a day and washing off the pulp to obtain the nut. The nut is sun-dried for two days if cold water was used and for eight hours if hot water was used to soak the fruit. The kernel is obtained from the nut by cracking with stone on top of another stone or metal. Oil is extracted from the kernel by heating its meal in a pan over an open fire or boiling it in a pot containing water. The most difficult and risky aspect of all the operations is the cracking of the nuts to bring out the kernel.

The wide variation in shape and size of the nuts makes it difficult for one to apply uniform force in cracking. If the cracking force is too high, about 40% of the kernels get damaged. Proper understanding of the mechanical properties of *Balanitesaegyptica* nut is considered necessary in the design of appropriate machines for different postharvest operations such as cracking, cutting, crushing and grinding.

MATERIALS AND METHODS

Research Design

This chapter discusses the various methods used in carrying out the research from sampling of the study communities through to the collection, presentation of data and findings. The profile of the upper west region is also discussed in relations to issues relevant to the topic. The case study approach was used in the study to identify the Jirapa and Nadowli Districts for the study. Quantitative and qualitative approaches were used from planning and related institutions. These approaches helped in appreciating the usefulness of the existing literature in the study and the relevant contribution they make in unveiling in-depth information from respondents in their own language and environment.

Sampling Design

Both probability and non-probability sampling techniques were used. In sampling design, characteristics of population are vividly indicated. The sampling design for the study comprises the employment of purposive sampling and sample selection; this helped the researcher to have the idea about the existing social situation. An in-depth knowledge about the parameters of the population helps the investigator to determine the type of sampling design.

Purposive sampling

Purposive sampling was used under the non-probability sampling to collect data from people who use the desert date for various purposes in the region. The rationale behind employing this judgment sample was to identify communities that have intense use of the desert date. Key informants such as herbalists, farmers (males and females), and anybody within the community who knew the plant and has used its products were identified and structured questionnaires administered separately.

Sample selection.

The multi-stage technique was adopted for the study. The first involved the selection of the Districts; the second involved the selection of the communities at random while the third involved a laboratory analysis of the edible parts of the plant. In the Jirapa District, communities selected were Tizza, Ullo, Kaani, Duori, and Moyiri. While in the Nadowli District, communities selected were Kaleo, Loho, Duong, Daffiama and Sombo. Two herbalists were interviewed in both Districts to find out the medicinal use of the plant while fifty questionnaires were administered in each district to other respondents on the uses of the plant in general. In all a total of 102 questionnaires were used for the study.

Research Tools

The study employed structured and semi-structured interviews and a proximate analysis of the leaves and fruits in the laboratory to find out the uses and the nutritional components of the plant. The essence of this activity was to ascertain the world view of persons with regards to the issue at hand.

Questionnaire Design

In general, the parameters considered in the design of the questionnaire included the social background of respondents, harvesting, uses, processing and preservation and medicinal uses of the desert date products. Two questionnaires were designed for people who use, process and preserve as well as the difficulties or constraints in harvesting the desert date.

Nutritional composition Determination.

The research was concluded with an analysis of the nutritional composition of the leaves and the fruits at the laboratory of the Department of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology (KNUST). Samples of the leaves were taken from the study areas for analysis. The samples were taken through the methodology described below.

Crude Protein Determination by Kjeldahl Method

Digestion

Weigh 2g air dry sample into 500ml long-necked kjeldahl flask and 10ml distilled water to moisten the sample. Add 1 spatula full of kjeldahl catalyst (mixture of 1 part selenium + 10 parts $CUSO_4$ + 100 parts Na_2SO_4), followed by 20ml conc. H_2SO_4. Digest until the solution clear and colourless. Allow the flask to cool, decant the fluid into a 100ml volumetric flask and make up to the mark with distilled water.

Distillation

Transfer an aliquot of 10ml fluid from the digested sample by means of a pipette into kjeldahl distillation flask. Add 90ml of distilled water to make it up to 100ml in the distillation flask. Add or dispense 20ml of 40% NaOH to the content of the distillation flask. Collect distillate over 10ml of 4% boric acid and 3 drops of mixed indicator in a 200ml conical flask. The presence of nitrogen gives a light blue colour.

Titration.

Titrate collected distillate (about 100ml) with 0.1N HCL till the blue colour changes to grey and then suddenly flashes to pink.

A blank determination must necessarily be carried out without a sample.

Calculation

Weight of sample used, considering the dilution and the aliquot taken for distillation = 2g x 10ml/100ml= 0.2g

%N = 14X (A-B) X NX 100/(1000X0.2)

Where,

A=volume of standard HCL used in sample titration

B= volume of standard HCL used in blank titration

N=normality of standard HCL

% Crude Protein (CP) =% Total Nitrogen (NT) X 6.25(protein factor)

Crude Fat

Method

Fold a piece of filter paper in such a way to hold the sample. Wrap around a second filter, which is left open at the top like a thimble. A piece of cotton wool is placed at the top to evenly distribute the solvent as it drops on the sample during extraction). Weigh into an extraction thimble/folded filter paper 2g of the dried sample (residue from dry matter determination can be used). Place the thimble inside the Soxhlet apparatus. Connect a dry pre-weighed solvent flask beneath the apparatus and add the required quantity of solvent and connect to condenser. The sample was extracted with petroleum ether for 4 – 6 hours. On completion, remove the thimble and reclaim ether using the apparatus. Complete the removal of ether on a boiling bath and dry flask at 105°C for 30 min. Cool in a desiccator and weigh.

Calculation:

Crude fat (% of DM)

$$= \frac{\text{weight of fat}}{\text{weight of sample}} \times \frac{100}{1}$$

Crude Fibre

Method

Transfer about 2 g of the dried, fat-free sample into a digestion flask. Add 200 ml of hot/boiling sulphuric acid, place the digestion flask under the condenser, and bring to, boiling within 1 min. Boil gently for exactly 30 min, use antifoam if necessary. At the end of 30 minutes, filter immediately through the linen and wash with boiling water until washings are no longer acidic. Transfer residue back to the digestion flask and add 200 ml hot sodium hydroxide solution. Replace under the condenser and again bring to boil within 1 min. After boiling for exactly 30 min, filter through porous crucible and wash with boiling water, wash with about 15ml of 95% ethanol. Dry crucible and content at 110°C, to constant weight, cool in a desiccator and weigh. Ash at 550°C for 30 minutes, cools, and weigh. Calculate the weight of fibre by difference.

Calculation:

Crude fibre (% of fat-free DM)

$$= \frac{(\text{weight crucible} + \text{dried residue}) - (\text{weight crucible} + \text{ashed residue})}{(\text{weight of sample})} \times 100$$

Ash

Procedure

Preheat ash crucibles in an oven, cool in a desiccator and weigh. Weigh a 2 g sample into a dry, tared porcelain dish and then place in a muffle furnace at 600°C for 4 hours. Cool in a desiccator and weigh.

Calculation:

Ash (%)

$$= \frac{\text{weight of ash}}{\text{weight of sample}} \times 100$$

Moisture

Procedure

Weigh and place 2 g of the sample in a pre-weighed glass weighing can. Dry to constant weight at 100-105°C in a drying oven. Cool crucible plus sample in a desiccator and re-weigh.

Calculation:

$$\text{Moisture content (\%)} = \frac{\text{Weight fresh sample} - \text{Weight dry sample}}{\text{Weight fresh sample}} \times 100.$$

Pre-Treatment of Samples

Dry Ashing and Acid Digestion of Samples For, Na+, K+, and Fe_2+

Determination

The plant samples were ashed at 600°C by placing a suitable weight (1.0 g) of the sample in a silica crucible and heating it in a muffle furnace for 4 hours. The ash residue was dissolved in dilute HCl (1:1), filtered through acid-washed filter paper in a 100-ml volumetric flask, and the volume was made up to the mark with distilled water.

Determination of Potassium (K+) and Sodium (Na+) By Flame Photometer Method

Principle

When solutions of K^+ or Na^+ are drawn into a non-luminous flame, the ion in the solution burn and acquire energy hence move to higher energy level. After they return to lower energy level, radiations are emitted.

The emission of radiation has a characteristic wave length depending on the element concerned. The emission is detected by specific filters and photocell. The emission is then converted to electrical signal which is read out on a meter. The intensity of the emission is directly proportional to the read out or the detection of the meter.

Procedure

Aspirate each serial standard starting from the least and note the readout. Aspirate the unknown and record the read out.

Calculation

Plot a standard or calibration curve from the standard values and generate the equation. From the equation the various concentrations of the unknown can be calculated.

Determination of Iron (Fe^{2+}) By 1, 10-Phenanthroline Method

Principle

In either acidic or basic medium 1, 10-phenanthroline cans complex Fe^{2+} to form intense colour. This colour is then measured on spectrophotometer at 520 nm. Addition of ascorbic acid or hydroxylamine hydrogen chloride reduces any fe3+ which might be in the unknown sample.

Procedure

To each 0.2ml of each serial standard/sample, add 1.0ml of ascorbic acid. Add 1.0ml of 1, 10-phenanthroline. Incubate at room temperature for 20 minutes. Read the absorbance at 520nm on the spectrophotometer.

Calculation

A standard or calibration curve is plotted from the standard values. From the equation of the curve (line) the concentration of the unknowns/samples are calculated

Determination of nitrogen free extract

Nitrogen Free Extract (NFE) was calculated on as fed basis by difference after analysis of all the other items method in the proximate analysis.

NFE = (100-% moisture + % crude protein + % crude fat + % crude fiber + % ash)

Energy calculation

The percent calories in the samples were calculated by multiplying the percentage of crude protein and carbohydrate with 4 and crude fat with 9. The values were then converted to calories per 100gm of the sample.

Total Carbohydrate calculation

The percent total carbohydrate in the samples were calculated by adding the percentage of crude fibre and nitrogen free extract

Total Carbohydrate = % Cr bre + % NFE

RESULTS

Harvesting of the leaves.

The study conducted in the communities showed that 95% of the total population interviewed revealed that they harvest the leaves of the plant for various uses. They however, have different methods of harvesting the leaves. The figure below shows the various methods of harvesting and their respective frequencies and percentages.

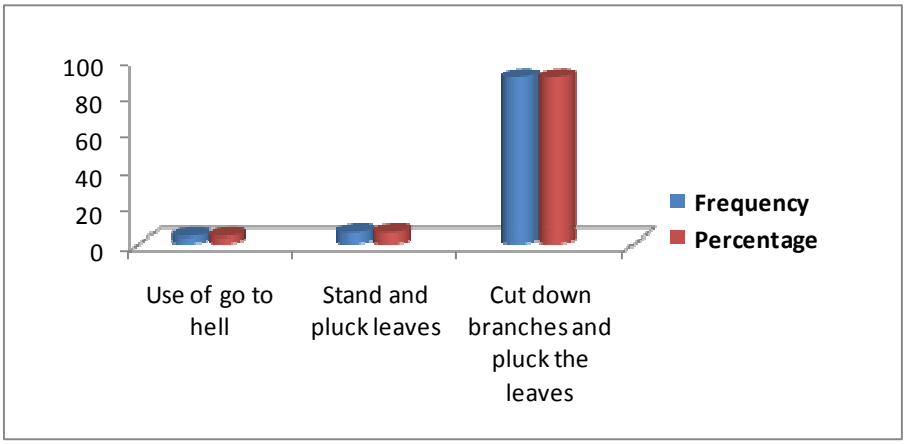

Figure 1: methods of harvesting

Source: Field Survey January, 2011.

The figure above shows that ninety percent (90%) of the respondents harvest the leaves of the desert date by cutting down the branches and plucking the leaves, also, 6% stand and pluck the leaves and 4% of the population use go to hell to harvest the leaves.

Production of edible leaves.

The survey also revealed that 82 respondents representing 82% of the population observed that production of leaves which are soft and is cooked and eaten as vegetable sprout from the nodes of the branches during the dry season with the peak production realized around January to march and 10% responded production of leaves is around July and September while 8% said the production is around April to June. This can be shown is the table below.

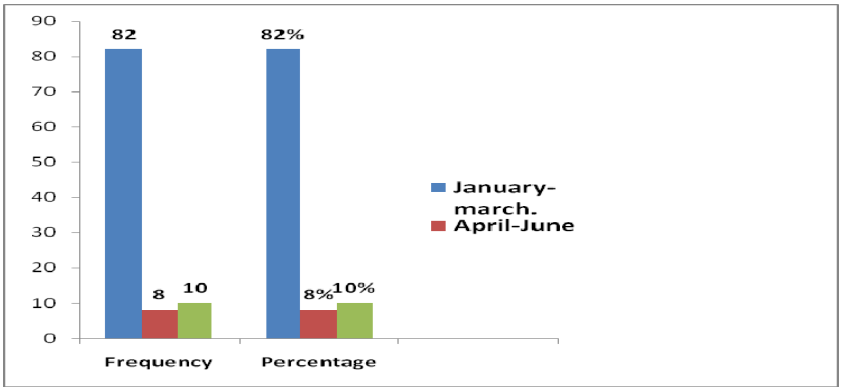

Figure 2: Productions of leaves all year round

Source: field survey January, 2011

Table 1: Processing and preservation of leaves

Method	Percentage	Frequency
Drying	15	15
Boiling	17	17
Boil and dry	68	68
Total	100	100

Uses of the leaves.

The leaves of the desert date in the two Districts of study had numerous uses. The table below shows some uses of the plant in the study area.

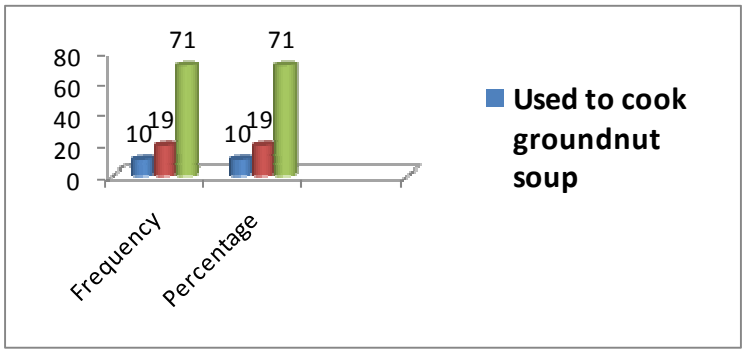

Figure 3: Uses of the Leaves

The table above shows clearly that 71 respondents representing 71% of the total population boil the leaves and add it to an accompanied meal locally called 'koose', 19% boil the leaves and add maize or beans flour to it and eat it as a meal. While 10% cook the leaves with groundnut paste.

Processingand preservation of the fruit

The fruit of the desert date is preserved by drying. 48% said if well dried can stay above three months while 30% confirmed it can stay for between two and three months and 8% said it can stay between one and two months 14% of the respondents didn't know how long it could stay after drying. The figure below shows a range of months it takes to preserve the fruits.

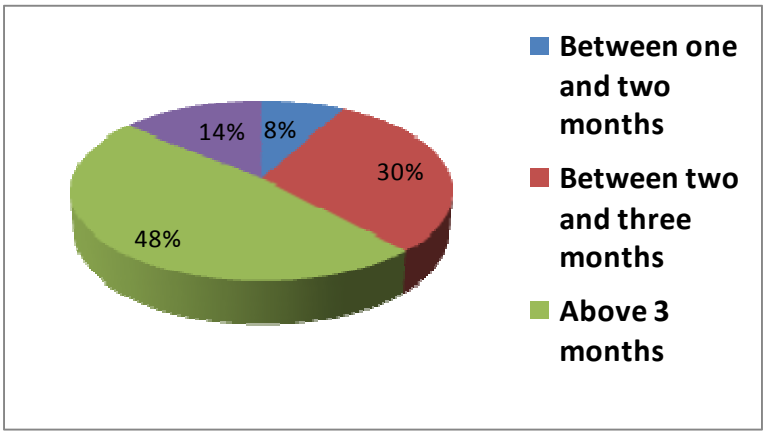

Figure 4: Range of preservation of products

Table 2: Edible uses of the fruit.

uses	frequency	percentage
Lick pulp	77	77
Soak in water and drink	23	23
Total	100	100

The fruit of the plant is edible as the whole of the population indicated in the survey. 77% indicated they peel the off the cover and lick and 23% peel of the coat soak in water to serve as a drink.

Other uses of the plant

Apart from the use of the plant as food for man, the desert date plant has other uses. The chart below shows various uses of the plant.

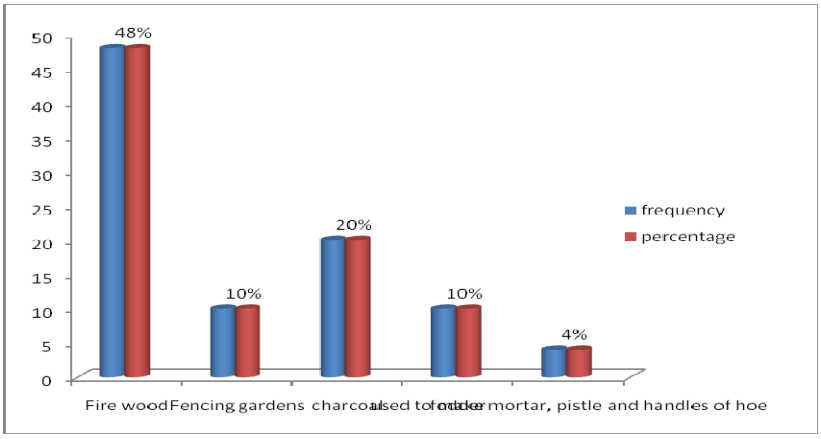

Figure 5: Other uses of the plant

The figure above shows various uses of the plant as it indicated that 48% of the populations use the stem of the plant for fire wood. Twenty (20%) percent burn the stem as charcoal for cooking. Ten (10%) each of the population use it for fencing and fodder respectively while four (4%) use it to make mortar pestles and handles of hoe's. The leaves are also used to feed animals during the dry season.

Medicinal use of the plant

Table 3: Medicinal uses of desert date

Treatment	percentage	frequency
Stomach pains	48	48
Enhance milk production in lactating mothers	22	22
malaria	25	25
fits	5	5
Total	100	100

Source field survey; January, 2011

The leaves, fruits, and roots have medicinal uses. They are however added to ingredients for treating ailments. The table above shows that 48% of the respondents use it to treat stomach pains, 22% a lactating mothers take to enhance breast milk production,25% use the leaves to treat malaria while 5% use it to treat fits.

Table 4: Cultivation of the plant

Cultivate	Percentage	Frequency
Yes	3	3
No	97	97
Total	100	100

Source field survey; January, 2011

The desert date grows mostly in the savanna areas and in the wild. Because it grows in the wild, no effort has been made to cultivate it in the area as ninety seven percent (97%) of the respondents testified while 3% cultivate it.

Table 5: Some Nutritional Components of the Desert Date

	% composition of leaves	% composition of fruits
Crude protein	17.06	3.85
Crude fat	2.32	1.38
Crude fibre	16.02	8.72
Carbohydrates	30.92	59.53
moisture	41.41	24.63
Iron	0.05	0.04
Sodium	0.03	0.06
potassium	0.52	1.11
Ash	8.27	10.63
Nitrogen free extract	14.90	50.81
Total energy	277.02cal/100g	231.02 Cal/100g

Triplicate analysis of the desert date fruits and leaves

Source; Department of Renewable Natural Resource Laboratory (KNUST). August, 2011

Table 6: t- test results comparing nutrient composition of leaves and fruits of the desert date

Pair composition of F&L	PAIRED DIFFERENCE							
	Mean	Std. deviation	Std. error mean	95%confidence interval of diff.		t	df.	Sig. (2-tailed)
				lower	upper			
Crude protein	8.95500	8.63377	6.10500	-68.61638	86.52638	1.467	1	.381
Crude fat	.36000	.02828	.02000	.10588	.61412	18.000	1	.035
Crude fibre	1.08700E1	4.45477	3.15000	-29.15454	50.89454	3.451	1	.180
carbohydrates	4.37250E1	20.93743	14.80500	-144.39036	231.84036	2.953	1	.208
moisture	3.15200E1	11.15815	7.89000	-68.73196	131.77196	3.995	1	.156
iron	1.079500E0	.649831	.459500	-6.918001	4.759001	-2.349	1	.256
sodium	6.643500E0	4.893886	3.460500	-37.326321	50.613321	1.920	1	.306
potassium	-1.032500E0	.881762	.623500	6.889819	6.889819	-1.656	1	.346
Ash	7.95000	2.37588	1.68000	-13.39642	29.29642	4.732	1	.133
Nitrogen free extract	3.13550E1	26.09931	18.45500	-203.13801	265.84801	1.699	1	.339
Total energy	2.52520E2	31.81981	22.50000	-33.36961	538.40961	11.223	1	.057

P<0.05 means there is significant difference between treatments but if p>0.05 means there is no significant difference between treatments

DISCUSSION

The study revealed that three methods of harvesting existed in the harvesting of the leaves of the desert date. Majority of the respondents cut down the branches and pluck the leaves, this they explained that the tree is thorny as such cannot be climbed. The thorny nature of the tree is confirmed by Tredgold, [11] who stated that the tree is thorny as such used to make livestock enclosures. The findings also revealed that some respondents stand by the tree and pluck the leaves because some of the trees are short which is in line with Grace [5] that the tree has round crown, spreading, sometimes with low branches remaining close to the trunk.

Production of Leaves

Production of leaves from the results shows that it mostly occurs between January and March which is the dry season. This is also confirmed by FAO, [4] who stated that foliage production of the desert date occur at the height of the dry season. The production of fresh leaves at the dry season makes it an important plant in the study area as the leaves are always available at times that vegetables are scarce in the area.

Uses of the Leaves

Three distinct methods of using the leaves which is edible were revealed in the study area. A very high percentage of 71 boil the leaves and add it to another meal called ‘koose’ or ‘sense’ made from grounded beans flour and eaten. Some also boil the leaves and add either fried maize flour or beans flour to it and boil again to form a meal popularly known as ‘sewale’. Both the young and old enjoy the meal it makes one drink a lot of water as such does not feel hungry all day. Apart from these some also boil the fresh leaves or boil and dry the leaves and use it to prepare groundnut soup, it is either eaten alone or eaten with TZ. All these uses in terms of food have been confirmed by Stewart and Brandis [10], that young leaves and tender shoots are used as vegetables.

Processing of the Leaves

The most common method of processing and preserving the leaves of the desert date is through boiling and drying of the leaves which 68% of the respondents mentioned. They indicated that young leaves are boiled to get soft and then dried. This extents the shelf life to more than four months without going bad. Others also boil the leaves to preserve but this can only stay for about two days or more with repeated heating daily.

Processing/ Preservation of the Fruits

The fruit of the desert date is preserved by drying. When the fruits are well dried they are able to store for more than three months as 48% of the respondents testified. This is due to the fact that when it is well dried pest don't easily attack and destroy them.

Uses of the Fruits

Two main uses of the fruit were identified in the study area. Majority of the respondents peel off the cover/coat of the fruit and lick the pulp, others also peel off the coat/cover of the fruit soak it in water overnight and taken as a drink. This agrees with there port by Steward and Brandis, [10] that the fruit is processed into drink and alcoholic liquor in Nigeria.

Other Uses of the plant

Five major uses of the plant were identified. The desert date plant are used to make firewood, fence gardens, making charcoal, used as fodder for livestock and for making mortar, pestle and handles of hoes. The results indicated that the plant is used for firewood in the study area. This is in line with Steward and Brandis, [10] who reported that the wood is good firewood; it produces considerable heat and very little smoke, making it particularly suitable for indoor use.

It was also revealed that the wood was used in making pestles, mortars and handles of hoes which Grace and sands, [5] confirmed that the wood is hard, durable and can make pestles, mortars, handles, stools and combs. Apart from these, others also revealed that the fresh and dried leaves are eaten by animals in the area as Steward and Brandis, [10] reported in their study that the fresh leaves and dry leaves, fruits and sprouts are all eaten by livestock. They further revealed that in Burkina Faso, the desert date contributed up to 38% of the dry matter intake in goats in the dry season. Because of the thorny nature of the branches 10% of the respondents use it to fence gardens around their homes to produce vegetables.

Medicinal Uses of the Plant

Herbal treatment of people in the study area is very common as the herbalist in these areas use various parts of plants including the desert date. The leaves, roots, stems and fruits are used as herbs to cure ailments.Some herbalist interviewed in the area revealed that they treat malaria, fits, and stomach pains with the desert date. Apart from these the roots of the plant are pounded and used for fishing because it is poisonous. This was reported by Tredgold, [11] that the compound is toxic to the fish but does not affect mammals and rapidly becomes inert, so that fish retrieved are edible. However, in the fader region of Cote d'ivoire, the poison is reported to damage the sight of fishermen after they have used it for 5-7 years.

Cultivation of the plant

Booth and Wickens, [3], reported that there are plantations of the species in Cape Verd Island, the Dominican Republic of Puerto Rica. Plantation has been reported in India, individual trees are planted extensively in Africa and a small plantation has been established in Niger, Chad and northern Nigeria. In Ghana and the study area in particular showed that no attempt has been made to grow the plant as 97% of the respondents indicated that it was a wild crop and there was need to grow cultivate it.

Nutritional composition of the leaves and the fruit of the Desert date.

According to the international institute of rural reconstruction [7] vegetables supply various nutrients for good health. The Desert date understudy equally provides these nutrients which the body needs. Despite the fact that it mostly grows in the savanna areas in Ghana where there is a prolonged dry season, the fresh leaves sprout out at which stage they are edible. This is hailed by the people because vegetables at that season are very scarce as such the leaves of the desert date are an asset to the people of the study area in the dry season. From the analysis, the leaves contain 41.41% of moisture, 17.34% of protein, 16.02% of fibre, and 30.92% of carbohydrates. From the analysis it is clear that the leaves are a source of good health when eaten.

This is confirmed by Abbey and Timpo, [1] that indigenous vegetables are under exploited either because of ignorance or arrogance, but that they have a high potential in combating nutrition-related problems, which the desert date leaves also does. Again, it has been found that indigenous leafy vegetables are richer in nutrients than their exotic counterparts [1]. People should therefore be encouraged to eat these indigenous vegetables more. The fruits of the desert date also have nutrients which are essential for the body; they have 59.53%of carbohydrates 231.02 Cal/100g of energy which humans need to work efficiently, 8.72% of fibre and 24.63% of moisture. These are evidence that the fruits and leaves of the desert date plant are good for the health of the people in the study area and Ghana as a whole.

REFERENCES

[1] Abbey, H. & Timpo, G. M. 1990. Production and utilization of indigenous leafy vegetables; a proposal intervention model for savannah zones of Ghana. Technical note Department of Horticulture, KNUST, Kumasi, Ghana.

[2] Abu-Al-Futuh, I. M. 1983. *Balanites aegyptiaca*: an unutilized raw material potential ready for agro-industrial exploitation. United Nations Industrial Development Organization.

[3] Booth, F. E. M. & Wickens, G. E. 1988. Non-Timber Uses of Selected Arid Zone Trees and Shrubs in Africa. Conservation Guide 19. FAO, Rome.

[4] FAO 1993.The state of food and agriculture 1993. (FAO Agriculture Series, no26) ISBN 92-5-103360-9.FAO, Rome.1993

[5] Grace, O. M. & Sands, M. J. S. 2007. *Balanites munghamii*. Sprague. In *PROTA 14: Vegetable oils/Oleagineut. [CD-ROM]*, eds. H. A. M. van der vossen & G. S. Mkamilo, PROTA. Wegenningin, Netherlands.

[6] Hall, J. B. & Walker, D. H. 1991. Balanites Aegyptiaca, A Monograph. University of Wales, Bangor.

[7] International Institute of Rural Reconstruction (IIRR). 1995. Environmentally sound technologies for women in Agriculture. Silang, Cavite, Philipines.

[8] Launert, E. 1963. Balanitaceae. In *Flora Zamesiaca*, eds. A. W. Exell, A. Fernandes & H. Wild, Vol. 1, Crown Agents. London, pp. 221 - 224.

[9] Shanks, E. & Shanks, P. 1993. *Balanites aegyptiaca: A handbook for extension workers*. School of Agricultural and Forest Sciences, University of Wales, Bangor, UK. Page 57-58

[10] Stewart, J. L. & Brandis, D. 1972. *The Forest Flora of Northwest and Central India:* A Handbook of the Indigenous Trees and Shrubs of those Countries. Bishen Singh Mahendra Pal Singh, Dehra Dun.

[11] Tredgold, M. H. 1986, 1990. Food Plants of Zimbabwe Mambo Press, Harare. Page 292-293