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EFFICACY OF CACTUS PEAR (*Opuntia ficus-indica*) VARIETIES AS A SOURCE OF FOOD AND FEED IN ENDAMEHONI DISTRICT, NORTHERN ETHIOPIA

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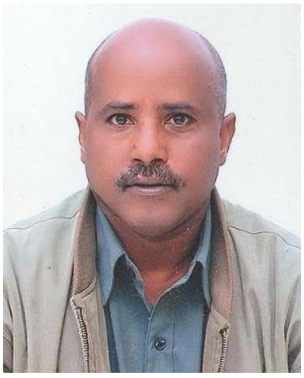

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ABSTRACT

Cactus Pear (*Opuntia ficus-indica*) serves as a source of food, feed, as well as a means of additional income to the people in northern Ethiopia. The species has different varieties with varied rate of productivity and palatability. This study was conducted to assess the food and feed value of the Cactus Pear varieties in Endamehoni District, northern Ethiopia. It was carried out in three "Tabias" (small administrative sub-districts) and nine sub-Tabias (also known as "Kushets"). These areas were purposively selected as they are well known for their good diversity of Cactus varieties. A total of one hundred and twenty households (n = 120) were randomly selected for interviews using a semi-structured interview. This was supplemented by information obtained through key informants' interviews and field visits. The local farmers made the identification and characterization of cactus varieties traditionally based on the outstanding phenotypes like fruit characteristics, seed size and content, cladode descriptors and plant height. A total of 13 Cactus varieties were identified and recorded. To assess the food and feed value and to select the best used varieties in the area, preference rankings were made. It was found that not all varieties were equally edible and palatable. The most serious constraints in palatability were associated with fruit taste, fruit size, presence of spines, and hardness of seeds. The ethnobotanical study on palatability was supplemented by chemical analysis on Dry Matter (DM), Ash, Organic Matter (OM) and Crude Protein (CP) content from two-year-old young cladodes of four Cactus varieties (Kille, Wadwada, Magalla and Limo) that are more preferred for food and feed. The analysis of variance (ANOVA) showed significant differences in DM, OM and Ash content at $p<0.05$ (not at $p<0.10$). There was no variation in crude protein content amongst the varieties tested. From the results, it is concluded that propagation and use of varieties Kille, Limo, Magalla and Wadwada by farmers of the area is advisable.

Key words: Characterization, Cladode, Community, ethnobotany, fruit, palatability, preference, propagation, traditional knowledge.

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INTRODUCTION

Semi-arid and arid regions are a challenge to conventional cropping systems because of limited or erratic rainfall, poor soils, and high temperature. Therefore, the search for the appropriate plant species that could be grown in these areas is of great importance. Previous studies showed that the future of arid and semi-arid regions depend on the development of sustainable agricultural systems and cultivation of appropriate crops [1, 2]. The types of crops to be cultivated must withstand water shortage, high temperature and poor soil fertility. Plant adaptability to marginal lands, ease of propagation, persistency, Dry Matter (DM) yield, digestibility and nitrogen content are also important aspects for nutrition [3]. In this regard, Cacti, particularly *Opuntia* species, meet all of the above requirements as a source of food for humans and feed for domestic animals and wildlife in arid and semi-arid regions [4]. These plants are adapted to withstand severe drought conditions and still produce fodder at low cost [5]. *Opuntia spp.* can also be used in agro-forestry systems with legumes and annual crops [6].

Within the genus *Opuntia*, Cactus Pear (*Opuntia ficus-indica*) is the most agronomically important species for the production of edible fruits and cladodes, which can be used as a vegetable and valuable forage resource in arid and semi-arid lands [7]. It is an efficient water utilizing xerophyte, and both the young cladodes and fruits are suitable for human consumption [8]. If developed further, this crop could contribute to sustainable food and feed production in countries, like Ethiopia, with large areas of semiarid and arid lands [9].

Tigray, a region in north Ethiopia, is a semi-arid area with limited agricultural potential, and is also well known for its livestock resource with critical feed shortage. More than 85% of the population in the region lives in rural areas with their main source of livelihood based on agriculture [10]. The people being directly dependent on agriculture for livelihood, with the unreliable rainfall compounded by ever-increasing human and livestock pressures on the land are food insecure [10]. Livestock production in such environments also faces challenges due to feed shortage.

Cactus Pear in Tigray is a good source of food, animal feed, and a means of additional income. Utilizing it in many ways is of paramount importance for the farmers [11]. The main production areas of Cactus Pear, in Tigray Region, are the eastern and southern zones [12]. However, to our knowledge, no study was conducted on the available varieties and their use (food/feed value) in the southern zone of the region. Considering this, our study was designed to identify and characterize the local Cactus Pear varieties with the help of farmers' indigenous knowledge and to further illustrate their efficacy and nutritional values as food and feed.

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MATERIALS AND METHODS

Description of the Study Area

The study was conducted in Endamehoni District, northern Ethiopia (Fig. 1). The District has an estimated total population of 84,726, of whom 2,985 (3.5%) are urban-dwellers [13]. It is divided into 18 "Tabias" (local administrative units of the district) and 70 sub-Tabias. The district is situated at an altitude ranging between 1700 and 3488 masl. The rainfall is bimodal, the Kremt season (June – September) and Belg season (January – March). The temperature varies from 6ºC to 32ºC [14]. Agricultural production, particularly mixed farming is the basis for the livelihoods of the people in the district and it is rainfed, relying on the Belg and the Kremt rains. Wheat and Barley are the main food crops, while Sorghum, Teff, Maize and Faba Bean are minor food crops. Pulses are the main cash crops. Natural pastures, cereal straws and Cactus (locally called Beles) are the major forages. The main livestock types are cattle, sheep and goats.

Figure 1: Location of the study area (Endamehoni District, North Ethiopia)

Study Design

Site selection

Selection of Tabias and Kushets was purposive, based on the diversity of Cactus varieties and accessibility to transport. Three Tabias, namely Hizba Teklehaimanot, Mekhan and Tahtai-Haya (Fig. 1) and nine Kushets (three Kushets from each Tabia)

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were taken as sample sites. These main potential Cactus-growing areas were identified in collaboration with the Bureau of Agriculture and Rural Development of the District.

Selection of informants

Systematic random sampling was used to select households for interviews. The sampled households were grouped into cactus-growers (CG = 96) and non-cactus growers (NCG = 24). The growers of Cactus Pear were also stratified into male and female household heads in order to include female household heads so that the data is representative of the whole community. Secondary data from the District administrative office assisted in developing the sampling frame. Fifty-three (n = 53), thirty-seven (n = 37) and thirty (n = 30) household heads from each Tabia (Hizba Teklehaimanot, Mekhan and Tahtai-Haya) were sampled, respectively. Sample sizes were proportional to total household size of each area.

Cactus Pear Variety Selection for Nutrient Content Analysis

Cladode samples of four local Cactus Pear varieties, namely: Kille, Limo, Wadwada and Magalla, which were widely distributed, frequently used as feed and more palatable to most of the livestock were taken as sample varieties purposively for nutrient analysis.

Data Collection

Baseline information was collected based on distribution, uses of the species, production, and utilization with particular emphasis on local farmers' traditional classification. The questionnaire was framed in such a way that the households could give information that was recent, easy to recall and could be filled directly by interviewing the selected households.

The Cactus varieties were identified and characterized with particular emphasis on their phenotypes based on the farmers' traditional knowledge, coupled with the Cactus morphological descriptor traits developed by IPGRI [15].

The respondents were asked to assign values for the degree of abundance, as very often distributed (76% or above), often distributed (between 51 and 75%), rarely distributed (between 26 and 50%) and very rarely distributed (25% or less). The most preferred varieties for food (humans) and feed (animals) were determined. Each informant was asked to assign the highest value (5) for most preferred variety and the lowest value (1) for the least preferred one [16]. These values were summed up, averaged and ranks given to each variety.

Nutrient Analysis

Nutrient content analysis of Cactus Pear varieties was conducted at Mekelle University. The samples were subjected to analysis for proximate feed components (dry matter, ash and organic matter) [17], and crude protein content by the Dumas method of combustion [18]. All chemical analyses were carried out in triplicates for each sample.

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Data Processing and Analysis

The collected raw data through field observation, household and key informant interviews, were summarized and analyzed using descriptive statistics. Data for quantitative chemical traits were subjected to analysis of variance using SAS (version 6) software.

RESULTS

Demographic Description of the Households

A total of 84% male and 16% female household respondents were interviewed. More than half of the respondents had family size between five and nine and age 30-50 years (Table 1). Accordingly, average family size of the households was 5.6 persons. Majority of the respondents (74.2%) were married. Almost all the households were farmers without additional occupation. With regard to literacy, 22.5% household heads were literate.

Local Cactus Pear Varieties in Endamohoni District

The farmers of Endamehoni District identified thirteen locally grown varieties of Cactus Pear that varied in their morphological characteristics (Appendix). Each identified variety had a specific local name (Table 2). This traditional classification was based on outstanding phenotypes like fruit characteristics that included taste, color, size and shape, which are basic fruit quality parameters (Table 3). Nearly 62% of the identified varieties in this study were with ovoid fruit shape. Farmers also used internal quality parameters such as total seed and water content for classification. The presence or absence of spines, amount of spine per fruit and cladode, height of the plant, size and shape of cladode were some of the additional criteria used.

Distribution and Uses of Cactus Pear Varieties as Food and Feed

Cactus was utilized for different purposes in Endamehoni. The community ranked the use of Cactus for human consumption and animal feed first, followed by live fence and source of income. Of the total 13 recorded local Cactus varieties in the area, nine varieties were found widely distributed and highly productive (Table 4). Based on the vote of informants, Limo, Kille, Magalla, Ashauh and Tesmi were the most preferred varieties for food, respectively (Table 5).

Similar to the Cactus fruit preferences by humans, differences in palatability preferences of cladodes of Cactus varieties by different animals were observed. The feed palatability preference of the selected Cactus varieties by different farm animals in Endamehoni District is presented in Table 4. Ninety seven percent of respondents used cactus cladode as forage, with Limo and Kille, two highly palatable varieties browsed by all livestock types. Limo was highly palatable (92%) to all livestock types followed by Kille (88%), and Kulkual-Bahri and Wadwada (80% each). Two varieties, Cheguar (40%) and Chewchawa (32%), were least palatable.

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Perception of the Community on Use Value of Cactus Varieties

The socioeconomic survey revealed that the different household respondents had different views/degrees of perception, attitude and knowledge regarding the use value of Cactus Pear. This resulted in rank value difference of Cactus use in the selected study sites of the District. The respondents from the different sites (Tabias) were asked to rank the degree of importance of Cactus for their use as human food, animal feed, source of income, live fence and other additional values (Fig. 2). Cactus is mostly used as feed (forage).

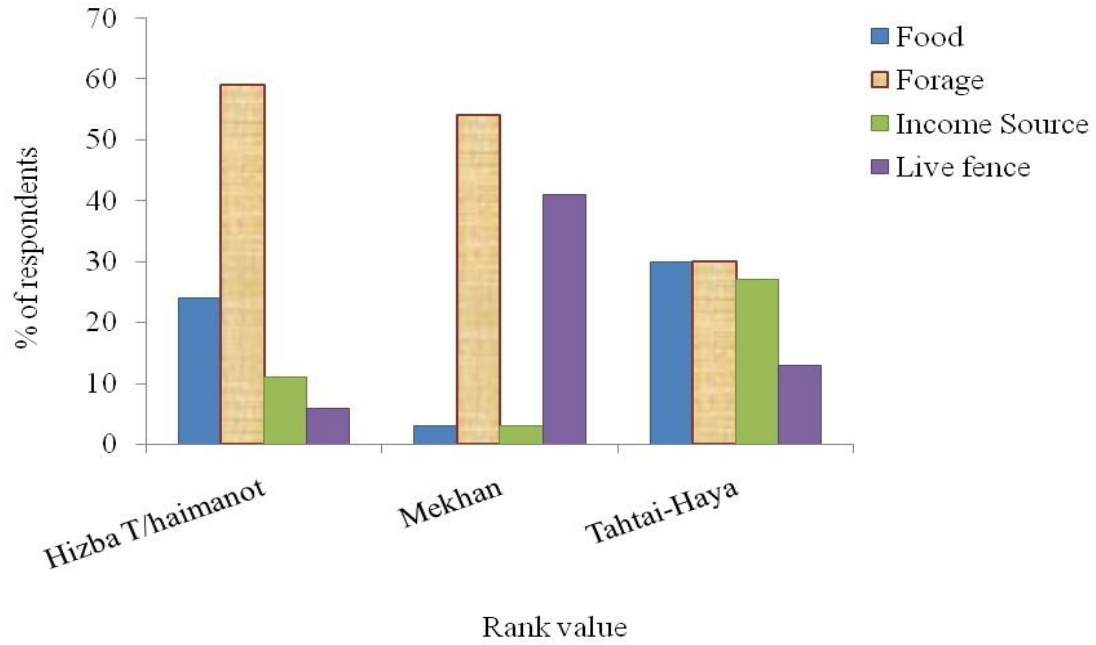

Figure 2: Rank of current uses of Cactus pear in three Tabias of Endamohoni District

Nutrient Content of Cactus Pear Varieties

1. Dry matter content (DM)

The dry matter content of the four selected Cactus varieties varied between 11.04 and 14.04% (Table 6). Highest dry matter content was recorded for Wadwada (14.04%) followed by Limo and Kille, 13.4% and 12.42%, respectively. The lowest average dry matter content (11.04 %) was observed for Magalla.

2. Ash content

The results in Table 6 indicate that the ash content of the Cactus varieties in the current study varied between 20.15 and 22.79%. The highest average ash content of 22.79% was noted for Wadwada variety. Likewise, least amount of ash was found in Kille (20.15%).

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3. Organic matter content (OM)

The organic matter content of different Cactus varieties ranged between 77.21% and 79.85% (Table 6). The highest and lowest average organic matter content of 79.85% and 77.21% were recorded for Kille and Wadwada varieties, respectively. The average OM content of the cladodes of different Cactus Pear varieties analyzed in this study was 78.94% of DM.

4. Crude protein content (CP)

The results shown in Table 6 indicate that the CP content of the varieties varied between 5.38% and 6.02%. Highest CP content was recorded for Limo (6.02%). However, the analysis of variance showed that there are no significant ($P>0.05$) differences in CP content among the Cactus varieties grown in the study area.

DISCUSSION

Germplasm characterization involved the compilation and maintenance of accurate records of the identifying traits. The traits included outstanding phenotypes like fruit characteristics, quality and cladode morphology [19]. Chessa and Nieddu [15] developed such descriptors for Cactus Pear.

Fruit Characteristics

Cactus Pear fruits are appreciated for their characteristic taste and aroma as well as their dietetic properties [20]. The varieties considered in this study showed variation in their fruit taste, peel and pulp fruit color. The community differentiates the varieties traditionally into two major categories by spine as “spiny” and “smooth”. Peel and pulp color are also important for variety identification. These methods were used to identify cactus varieties in Mexico [19]. Cactus Pear fruits are also classified according to shapes, namely: round, elliptic, ovoid, and oblong [15, 21]. Size and shape of Cactus fruit are important considerations when choosing a variety for cultivation. Varieties that have large fruit size and ovoid/oval shape are commercially accepted [22]. Oval fruits are easier to handle than elongated fruits. In addition, oval shaped fruits undergo less damage to the stem end during harvesting [20]. One of the attributes of the perfect Cactus Pear fruit is glochids that are easily removable by mechanical brushing [23].

Seed size of majority of the varieties was medium. One of the leading U.S. importers of Cactus Pears [24] as well as marketing surveys released in Italy [25] have suggested that one of the most important breeding objectives should be the development of low seedy varieties. Low seedy Cactus varieties are commercially acceptable because the fruits consisted almost entirely of pulp tissue. Consumers assess fruit quality on the appearance of the fruit at the point of sale, and thereafter by its taste [26]. Appearance in turn is determined by fruit size and color [27]. Cantwell [20] also suggested that in Cactus Pear fruit quality is based on sugar content, peel color, fruit weight, pulp weight, and seed content. Accordingly, from the current study it is concluded that Limo, Kille and Magalla were the varieties that remarkably fulfill the criteria for quality fruit described by the above authors.

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Plant Height and Cladode Characteristics

Majority of the identified varieties were with medium plant height, cladode number and size. Cladode spine abundance of the local varieties also contributed to their variability. Spine type and number, food- and feed-use preference of Cactus varieties seem to be inversely related. The degree of difficulty in removing these spines can influence the food and feed value preference of Cactus varieties. Spineless cladodes are preferred since spine removal from the cladode area is easier than for spiny cladodes [28]. The present study revealed that four varieties with good spineless cladode number or with easily removable spines, namely Limo, Kille Wadwada (for animal feed only), and Magalla could be well-preferred varieties for human food and animal feed.

Distribution of Cactus Varieties

Cactus cultivation in northern Ethiopia is predominantly found on marginal lands, of which about half is planted while the remainder is wild [29]. Both spiny and spineless varieties occur on rangelands of the region [29]. The reason for differences in distribution could be the varieties' ecological adaptation, ease of accessibility, productivity, multipurpose use values of the plant, and farmers' indigenous knowledge of each Cactus Pear variety. Magalla, Kille, Limo, Wadwada, Ashahau and Cheguar were identified as varieties commonly planted in farmers' backyards for their food and feed value and for fencing home gardens. The thorny varieties of Cheguar and Ashauh were planted on homesteads and prescribed mainly for boundary demarcation and protection of home gardens.

Uses of Cactus Pear Varieties as Food and Feed

Based on the vote of informants, Limo and Kille were best used as food and feed. The fruit taste, size, nature of spines and lower seed number made them preferred over others. There were nevertheless slight differences in preference of edible fruit of Cactus varieties between study Kushets within the district, which could be mainly because of productivity. Different livestock were also reported to browse different Cactus varieties for feed with different degree of preference; Camel was ranked first as the best browser of all the listed varieties, followed by equine and cattle. Sheep browsed on eight varieties and Goat browsed on seven varieties. The local farmers believed that selectivity and palatability preference of Cactus cladodes by different animals is mainly based on the morphological nature of the plant, like spine abundance and cladode age. The results revealed that at Hizba Teklehaimanot about 59% of the respondents gave priority ranking to the use of Cactus as a source of animal feed. Cactus delivers human food as fruit and vegetable, fresh and processed, animal fodder including even water supply, medicine and cosmetic, erosion control, fencing as well as wind break [30]. However, in Endamohoni the main uses are for food (fruit), feed (cladode), live fence and source of income.

Commercial Value

The consumption of Cactus fruit is the most common form of Cactus use in the study area. The fruit was also source of income to school children and women engaged in fruit selling. The plant has high commercial potential as it can be processed easily. It has also international market that may serve as source of foreign currency for the

country. People in Tigray, especially in eastern zone, are now involved in preparing and selling Cactus products like juice, cacke, marmalade (from fruit and stem) and even salad from Cactus products [29]. Nevertheless, in the current study site these products were not processed and utilized, which needs the attention and encouragement of the concerned bodies.

Chemical Analysis of Cactus Pear Varieties

Dry matter is the component left in feed after drying and is strongly influenced by many factors including species genotype, soil, climate, and season. The cladodes of different Cactus Pear varieties analyzed in this study had a high average moisture content (89.96%), which could hamper the dry matter (DM) intake by animals. This result is quite similar with the moisture content (mean value, 90.87%) of different *O. ficus-indica* recorded in South Africa by Hugh Mciteka [31]. Younger cladodes have the highest moisture content, and are more palatable due to their low fiber composition. The intake of DM can, therefore, be increased if the fresh cladodes are wilted or dried before feeding. Animals consume more DM in the form of hay compared to wet material [3]. However, watering animals during summer and drought periods is a serious challenge in arid regions and as a result feeding animals with Cactus cladodes supply additional water in dry areas.

Feedstuffs with high protein content are considered high quality fodders. The results of this study indicate that the CP content of the varieties varied between 5.38 and 6.02% on a DM basis. An average of 5.5% CP values for different *O. ficus-indica* cladode varieties were recorded in South Africa by Hugh Mciteka [31]. Pimienta [32] also reported average mean values of 5.4% and 4.2% of CP for cladodes with one year and two years age. Similarly, in this study low CP mean values of 5.78% on DM basis were noted. However, Tegegne [33] believed Ethiopian Opuntia to be moderate in CP in relation to ruminant requirements for a diet. He recorded an average of 9.15% CP for two-year-old cladodes of Cactus, which is higher than that obtained in this study. The difference could be explained by harvesting time, topography, agro-climatic conditions, soil type and the like of the selected area. Moreover, the CP content of the varieties in Endamehoni district is less than the 7% requirement for efficient ruminant function [34].

CONCLUSION

The widespread use of Cactus varieties in Endamehoni District is attributed to cultural acceptability, efficacy as livestock feed and human consumption, physical accessibility and economic affordability. The study clearly showed that varieties Limo and Kille were equally best as food and feed followed by Magalla as food and Wadwada as feed. Limo and Kille are not only preferred for food and feed but also have the best organic matter and crude protein content. Mean values for organic matter content of these varieties was significantly higher ($p < 0.05$) than some of the other varieties. Cattle, camel and equines feed on cactus varieties most, compared to goats and sheep.

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RECOMMENDATION

Based on the findings of this study, the community is advised to cultivate Limo, Kille, Wadwada and Magalla. However, part of this study done on variety identification using farmers' traditional knowledge and Cactus morphological descriptor traits needs to be further refined and confirmed with physiological and molecular studies.

ACKNOWLEDGEMENTS

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Table 1: Distribution of sampled household heads by age, family size, marital status, educational status and occupation

Tabia	Age of household head (year)			Family size				Marital status (%)			Education (%)		Occupation (%)	
	< 30	30-50	> 50	< 3	3-4	5-9	> 9	Single	Married	Divorced	Literate	Illiterate	Farming only	Off farm
T_1	7%	21.7%	13.3%	4%	11%	27%	1%	11.3	69.8	18.9	26.4	73.6	96.2	3.8
T_2	3.4%	19%	9.6%	7.3%	3.1%	16.3%	1.3%	2.7	78.4	18.9	18.9	81.1	86.5	13.5
T_3	4.6%	11%	10.4%	2%	5.9%	20%	1%	16.7	76.7	6.7	20	80	96.7	3.3
Total	18	62	40	16	24	76	4	10	74.2	15.8	22.5	77.5	93.3	6.7

Legend

T_1 = Hizba T/haimanot; T_2 = Mekhan; T_3 = Tahtai-Haya

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Table 2: List of Cactus Pear varieties identified by the community and their local nomenclature

S.N	Vernacular name (Tigrigna)	Reason for Naming	Meaning
1	Tesmi/Tesemsema (Shum)	Response after eating	Oily
2	Brki-Abo berhe (Wadwada)	After a person	Berhe's choice
3	Magalla hailu (Magalla)	After a person	Hailu's choice
4	Tinkish (Shenkor/Karemelle)	After taste	Sweet /candy
5	Kulkual-Bahri	Origin	Introduced (exotic)
6	Ashauh (Keyh Beles)	Spine abundance and color	Spiny and Red
7	Kille (Atsamo)	Pulp firmness	Firm
8	Cheguar	Glochid abundance	Hairy
9	Chewchawa	Color and taste	White and Salty
10	Tsaeda Aona	Color and appearance	White building
11	Menchaba	After taste	Boiled milk
12	Limo	Spine abundance	Spineless
13	Lematse	Cladode texture and absence of spines	Smooth and Spine less

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Table 3: Fruit characteristics used by the community for the identification of O. ficus-indica varieties

Morphological trait descriptors		Variety
Fruit taste	Sweet (delicious)	Limo, Kille, Magalla, Tesemi, Lematse, Karmelle
	Watery (not sweet)	Kulkual-Bahri, Wadwada, Menchaba, Cheguar, Tsaeda aona
	Slightly salty	Chewchawa, Ashauh
Fruit peel and pulp color	Yellow - orange	Tesmi, Wadwada, Ashauh, Kille, Limo
	Yellow-green	Cheguar, Menchaba
	Red-orange	Magallaa, Lematse
	white	Kulkual Bahri, Tsaeda aona, Chewchawa
	Yellow-red	Karmelle
Fruit shape	Round	Karemelle, KulkualBahri, Menchaba, Lematse
	Ovoid	Tesmi, Wadwada, Megalla, Kille, Limo, Ashauh, Chguar, Chewchawa
	Oblong	Tsaeda aona
Fruit size	Small to medium	Karemelle, KulkualBahri, Chewchaw, Tsaeda aona
	Large	Tesmi, Wadwada, Cheguar, Menchaba, Limo, Kille
Seed size and number	Small seed size	Lematse
	Medium seed size	Kille, Limo, Tesmi, Ashauh, Cheguar, Chewchawa
	Large seed size	Wadwada, Magalla, Kulkual-Bahri
	Few seed number	Tesmi, KulkualBahri, Tsaeda aona, Limo
	Large seed number	Kille, Chewchawa, Wadwada, Menchaba
Plant height	Tall	Limo, Lematse
	Medium	Kille, Wadwada, Magalla, Ashauh, Cheguar
	Short	Kulkual Bahri, Chewchawa
Cladode characteristics	Few Spines	Limo and Lematse
	Spiny but easily removable	Magallaa, Wadwada and Kille
	More spines and hard to remove	Ashauh, Cheguar and Kulkual-Bahri

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Table 4: Preference ranking of nine selected Cactus Pear varieties based on their degree of palatability (feed for animals) as perceived by the informants

Variety / Local name	Livestock type					Mean Value	Rank	Remark
	Cattle	Goat	Sheep	Camel	Equine			
Limo	5	5	5	4	4	4.6	1st	Best
Cheguar	3	-	1	3	3	2	7th	Poor
Wadwada	4	3	4	5	4	4	3rd	V. good
Tesmi	3	2	2	3	3	2.6	6th	Good
Magalla	3	3	3	4	4	3.4	4th	Good
Chewchawa	3	3	1	2	2	1.6	8th	Poor
Ashauh	2	-	-	5	4	3	5th	Good
Kulkual-Bahri	4	3	3	5	5	4	3rd	V. good
Kille	5	4	3	5	5	4.4	2nd	V. good
Mean value	3.6	2.6	2.6	4	3.8	Overall mean		
Rank	3rd	4th	4th	1st	2nd	3.3		
Remark	V. good	Good	Good	V. good	V. good	Good		

Key: Highly Palatable (HP) = 5; Most Palatable (MP) = 4; Little Palatable (LP) = 3; Rarely Palatable (RP) = 2 and Not Palatable (NP) = 1

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Table 5: Preference of fruits of Cactus Pear varieties for food

Tabia list	Variety name									Mean	Rank
	Limo	Kille	Wadwada	Magalla	Ashauh	Menchaba	Tesmi	Cheguar	Chewchawa		
Hizba T/haimanot	5	5	1	4	4	2	3	2	1	3	2nd
Mekhan	5	5	1	4	5	2	4	2	2	3.3	1st
Tahtai-Haya	5	5	1	5	3	2	3	2	1	3	2nd
Mean value	5	5	1	4.3	4	2	3.3	2	1.3	Overall Mean	
Rank	1st	1st	7th	2nd	3rd	5th	4th	5th	6th	3.1	

Key: Highly Edible (HE) = 5; Most Edible (ME) = 4; Little Edible (LE) = 3; Rarely Edible (LE) = 2 and Not Edible (NE) = 1

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Table 6: The average cladode chemical composition of four selected Cactus Pear varieties based on dry matter content (Mean values based on three replicates)

Variety	DM %	Composition (%)		
		Ash %	OM %	CP %
Limo	$13.4^{a, c} \pm 0.22$	$20.89^{a, b} \pm 1.25$	$79.11^{a, b} \pm 1.25$	$6.02^{a} \pm 0.35$
Kille	$12.42^{c} \pm 0.46$	$20.15^{b} \pm 0.19$	$79.85^{b} \pm 0.19$	$5.79^{a} \pm 0.16$
Wadwada	$14.04^{a} \pm 0.63$	$22.79^{a} \pm 1.16$	$77.21^{a} \pm 1.16$	$5.38^{a} \pm 0.29$
Magalla	$11.04^{b} \pm 0.62$	$20.42^{b} \pm 0.36$	$79.58^{b} \pm 0.36$	$5.94^{a} \pm 0.27$
Means	12.73 ± 1.26	21.06 ± 1.31	78.94 ± 1.31	5.78 ± 0.35

$^{a, b, c,}$ = Columns with different superscripts are significantly different ($P < 0.05$)

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Appendix: Morphological features of Cactus pear varieties in Endamohoni District

Limo

Lematse cladodes and matured fruits

Menchaba

Tesmi

Kille

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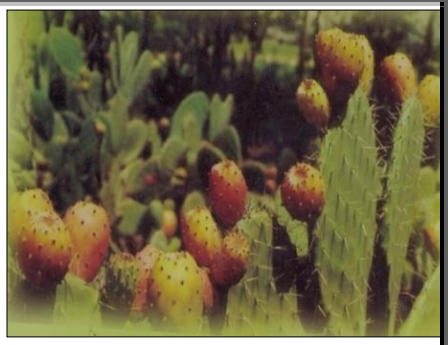
Wadwada

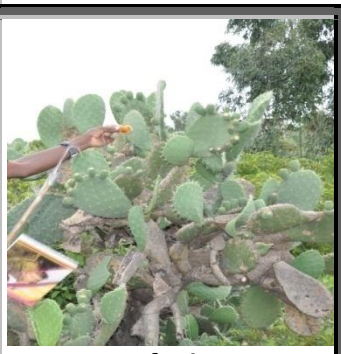
Cheguar

Chewchawa

Kulkual-Bahri Ashauh/keyh Beles



Matured Megalla fruits



Tsaeda Aona

Karmelle