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Qat farms in Yemen: Ecology, dangerous impacts and future promise

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ABSTRACT

Qat (*Catha edulis*) is an ever green tree/shrub naturally growing in Abyssinian mountains as well as in the other countries of East Africa. It has been introduced to Yemen before the Islamic Era, nowadays it is widely cultivated in the mountains of Sanaa and Taiz. The dark green leaves of qat are chewed in fresh condition by more than 90% of Yemen people. These leaves contain alkaloids similar to caffeine having pleasurable and mildly stimulating effects. Qat is, thus, classified by WHO as a “drug of abuse”. The present study describes the ecological features, including the physical environment and floristic composition, of qat farms in 12 sites in the mountains of Taiz (3 sites) and Sanaa (9sites) having altitudes of 1450 m and 2440 m, respectively. The chemical constituents of qat’s leaves collected from these mountains and the dangerous medicinal and socioeconomic impacts of qat’s cultivation on the Yemen’s people are described. A proposal that may help to control chewing and changing its cultivation from being harmful to be useful and profitable for Yemen’s people is discussed. Copyright © 2013, Mansoura University. Production and hosting by Elsevier B.V. All rights reserved.

1. Introduction

All plants on the earth have been created by the Great God for man’s benefits who is using them in all sorts of his life to eat, to heat, to feed his animals, to ease pains, to establish buildings, to manufacture clothes and furnitures etc. However, the progress of scientific researches, unfortunately, encouraged him to isolate and extract the active constituents of some medicinal

plants and divert them from their original purposes, i.e. they are no more useful medicinal plants but harmful narcotic drugs e.g. opium, hashish etc. this can be applied on Qat (*Catha edulis*) whose dark-green leaves contain alkaloids similar to caffeine and are chewed in fresh condition. Thus, WHO classified qat as a drug of abuse that produces wide to moderate psychic dependence. Since (1956) qat was recommended to the UN Commission as Narcotic Drug and the prohibition of qat

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cultivation and sale some way like hashish and opium due to its addictive effect and danger to the social life of the people.

Qat tree is not new but dates back to antiquity [1]. The ancient Greeks were smoking its leaves and Alexander the Great ordered his army to use qat as a medicine to prevent epidemics. Nowadays, large number of people in East Africa (Ethiopia, Eriterea, Kenya, Somaliland and Djibouti) and Yemen are chewing qat's leaves because of their pleasurable and stimulating effects. According to Al-Meshal [2], the consumption of qat is considerably increasing to the extent that in Yemen more than 90% of males and females at all levels of society have the habit of chewing qat leading to serious social and economic problems. Dahmash [3] stated that qat possesses an increasing socioeconomic problem but these appear to be no clear effective governmental policies providing guidance how to deal with the problem. Al-Dubai [4] stated that the habit of chewing qat's leaves prevented for centuries among the people of the Horn of Africa and the Arabian Peninsula including Yemen. Also, Al-Motarreh [5] referred to qat chewing as a social habit for central stimulant action of their cathinone content. However, for its dangerous impacts, qat's cultivation and consumption are illegal in Saudi Arabia where the government imposes very strong penalties against that. The reverse is true in Yemen, where for the increasing demand of qat for local consumption, the government is encouraging its cultivation on the expense of the coffee trees which are highly endangered or even extinct. The requirements of both trees are almost comparable. The first author of this paper recorded (1992–1994) few trees of coffee hidden between the thick farms of qat trees in Sanaa mountains. Only 5% of Yemen's population (farmers and merchants) are gaining a lot from qat cultivation, the remaining 95% are the consumers, i.e. most of the people are losers.

The present paper throws light on the ecology of qat farms in the mountains of Sanaa and Taiz of Yemen. Also, the catastrophic, medicinal, social and economic impacts of qat have been described. Logic and simple proposal that may help in finding an acceptable solution for the impacts of qat cultivation in Yemen by making use of the strong relationships between qat's tree and the Yemeni's people has been discussed.

2. The physical environment

Yemen occupies the southwestern corner of the Arabian Peninsula with an area of about 500,000 km², i.e. it covers about 15% of the total area of the Arabian Peninsula. It may be classified geographically into two sections [6]: northern section (NSRY) previously known as the Yemen Arab Republic with an area of about 200,000 km² and the southern section (SSRY) previously known as the Democratic Yemen Republic, with an area of about 300,000 km². The northern section of Yemen (Arabic Felix) that extends between latitudes 12°–18° N and longitude 42°–47° E, where qat cultivation is confined, may be categorized into five physiographic units. These are from Red Sea eastward:

1. Tihama coastal plain that extends for about 460 km along the Red Sea coast (maritime plain),
2. Red Sea coastal mountains (300–1500 m.a.s.l.),

3. Sanaa–Taiz central mountains (1500–3800 m.a.s.l.),
4. Wadi El Jawf (eastern plateau, 1000–1200 m.a.s.l.) and
5. The Empty Quarter (desert region).

The high altitude and the climatic conditions of the central mountains provide a favorable environment for qat cultivation which is mainly confined to Sanaa–Taiz sector characterized by the following climatic conditions [7]:

1. Annual rainfall ranges between 329 mm and 839 mm in Sanaa and Taiz respectively, mainly during April–July period,
2. Mean annual air temperature ranges between –1.0 °C and 9.2 °C (min.) and 21.1 °C and 35 °C (Max.), respectively.
3. Relative humidity ranges between 10% and 11.1% (min.) and 98% and 98% (Max.) and 51.2% and 59.0% (mean annual), respectively.

According to Al-Hubaishi and Muller-Hohenstein [8], the isolated mountain peaks, cliffs and rocky outcrops, bear neither soil nor vegetation. In steep slopes, there are stony, shallow and skeletal soils with dwarf shrub vegetation. In this environment the soil is fairly rich in nutrients, with pH > 7 and humus content >3% and are often protected by quite undisturbed vegetation. The soils of mountains in Yemen are intensively cultivated.

3. Material and methods

The field studies had been conducted in 12 sites selected at different altitudes (1450–2440 m.a.s.l.) of the Sanaa–Taiz mountains during 1992–1994. Anatomy of leaves, chemical analysis of soil samples had been carried out in the laboratories of Botany Department, Faculty of Science at Damietta, Damietta University and Sanaa (Sanaa University). The methods used are as follow:

3.1. Vegetation analysis

Twelve stands representing *C. edulis* were studied based on presence or absence of the associated species. The presence of each species is expressed by the percentage of stands in which it occurs. Presence percentage of species has been grouped into 5 classes according to Raunkaier [9]. In the field about 60 young branches of *C. edulis* from the twelve sites were collected. The leaves were separated into chewing (young leaves) and non-chewing (old leaves). Areas of young and old leaves were measured. Specimens of all taxa growing in the 12 sites of *C. edulis* cultivation in Yemen were collected and pressed on herbarium sheets according to Täckholm [10].

3.2. Soil and water analysis

Two soil samples were collected at two depths (0–20 cm and 20–40 cm) at different levels for six selected sites in Sanaa and Taiz mountains where qat grows. The soil samples were air-dried and subjected to physical and chemical analysis [11,12]. Twelve ground water (10–100 m depth wells) samples were collected from the twelve sites. Water samples were kept in polyethylene bottles for different analysis following Piper [11].

3.3. Chemical analysis and anatomical features of leaves

The leaf samples of *C. edulis* were collected from individuals growing in the 12 sites. Proline was determined in the leaves of qat according to Bates [13]. The total soluble –N (TN) was determined by the conventional micro-kjeldahl method [14]. For the preparation of thin sections of leaf of *C. edulis*, the paraffin method was used. The sections were examined using a research light microscope.

3.4. Data analysis

Two-Way Indicator Species Analysis (TWINSPAN) was applied to the classification of 12 sites of qat cultivation in Yemen, using the presence –absence data [15]. Canonical Correspondence Analysis (CCA) ordination [16] was used to ordinate vegetation with the environmental variables. The computer program CANOCO 3.12 [17] was used for all ordinations. The result is an ordination diagram (biplot) in which points represent species and sites and arrows represent environmental variables.

Data of various studies on *C. edulis* were analyzed by the least significant difference multiple range test [18] to determine significant difference among individual means for each altitude site. Pearson moment correlation coefficient was used to test the significance of the relationship between environmental and anatomical variables and species adaptive features (e.g. proline TN, CLA, ...etc.).

3.5. Status of Qat cultivation in Yemen

In Yemen there are about 40 kinds of qat grown at different altitudes. These include: Nahmy, Horry, Harazy, Sawtty, Seraty, Dulaea (upper area), Dulaea (middle area), Radaea, Garbany, Matary, Sharaby, Marary, Shamy, Sharw, Habashy, Bani, Hashish, Maswary, Samawy, Bokhary, Melahy, Mobarra, Nagary, Sabry, Khawalany, Hagawy, Sherky, Saddae, Khataby, Balady (Taazi), Obassy, Haramy, Gaeshany, Shamach, Maroh, Sharafy, Duhlla, Hamadany, Kootoby, Wadi Daher, Hadnany Afshy and Seiy, Baladi, etc. [19]. Shamy is of the midland is also called Shamach when grown in high land, it is the best quality, and its price may reach more than 5 times that of the other types and thus it is exported abroad. Such kinds of qat have different effects. Some make people happy and some cause sadness and anxiety. Some make the intestine hard and some soften it, some increase the sexual desire and some decrease it, but all kinds increases thirsty. Krikorian [20] on the other hand, distinguished these kinds of qat: one has an effect on the brain more powerful than that of opium or hashish and bring about madness a second kind less violent, causes only the inheriting effect of a spirit, the third kind still less strong only provokes insomnia. He attributed such difference due to the total alkaloids and the other chemical constituents of the chewing leaves which seems to vary with the age of the plant, the season of leaves harvesting and altitude of growth. The last feature perhaps is an indicative of the influence of climate and genetics.

Revri [21] reported that the natural growth and cultivation of qat plants are restricted to the high altitudes (1200–2400 m.a.s.l.) with at least 400 mm/year rainfall. Optimal development of qat plants has been observed at 600 mm/year rainfall

particularly in warm areas protected from frost with mean annual temperature of 19 °C, relative humidity of 90% and 13% (maximum and minimum, respectively) and with equal day and night length i.e. equatorial affinity. All of these requirements are available in Sanaa–Taiz high volcanic mountainous area in addition to its good drainage soils. Poorly drained soils may be salt affected not suitable for the growth of qat plants which seems sensitive to soil salinity. Smith [22] stated that the soils of qat cultivation in Yemen, apart from being well drained, are deep and fine textured with relatively high calcareous content, with gravely layers at different depth, moderately fertile, with low in nitrogen (0.05–0.08%), extremely variable in their phosphorus content, slightly to highly alkaline (pH = 7.4–9.0), with low salt concentration and without toxic elements (heavy metals).

Botta [23] stated that the environments of some mountainous villages in Yemen (1650–2200 m.a.s.l.) receive enough rainfall for a rich cultivation of qat. In lower mountains (1000–1650 m.a.s.l.) qat cultivation are irrigated with water obtained from the wells. Anonymous [24] reported that qat grown under drought condition is of better quality. On the other hand, qat seems salt non-tolerant plant never recorded in the salt affected lands of the Red Sea coast of Yemen [25].

Morghen and Rufat [26] showed that qat is cultivated from shoots as is done in case of banana or from cutting. Harvesting of chewing leaves is carried out all the year round (2–4 times/year). Only the small, young and fresh leaves and buds at the tip of the harvested branch are of value.

3.6. Chemistry and pharmacology of Qat

The chemical study of qat goes back to the nineteenth century Fluckiger and Gerock [27], searching for caffeine as the possible stimulating principle, found no traces of it but discovered instead an alkaloid they named kafin. Mosso [28] extracted from the plant (qat) a basic fraction with stimulant-like properties and called it as celastrine. Stockman [29] described three distinct alkaloids: cathine, cathinine and cathidine. Paris and Moysse [30] detected 3-6 alkaloids one of these might be ephedrine. Karawy [31] separated three alkaloidal products in addition to cathine and ephedrine: cathinine, cathidine and eduline.

The United Nation Narcotic Laboratory was able to identify and qualify the various properties of qat and substance named cathinone whose configuration was established in 1978 as alpha amino propiophenone [32,33]. The isolation of cathinone and the configuration of its amphetamine like effects is a crucial development in scientific knowledge on the chemistry of qat and its biological effects on the users.

Maitai [34] states that the euphoric and stimulating properties of qat has been known for many centuries. Of the earliest recorded reference of qat was in a medical prescription in the 13th century, aimed at relieving depression. Qat contains a narcotic substance that affects the nerves. It narcotizes them so that the person feels a sense of expansiveness and relaxation. It diminishes one's appetite for food and increases the desire to drink water.

Paris and Moysse [30] detected some tannins of flavonoid nature, glycosides of kaempferol, quercetin, and myricetin. In addition several amino acids, sugar, alcohol and ascorbic acid were also isolated from qat. Hill [35] mentioned that

considerable quantity of ascorbic acid and tannins were found in qat along with less amounts of resins, sugars and sugar alcoholic. Ascorbic acid influences not only on consumer nutrition but on the pharmacological effect of the plant. Tannins are probably responsible for the gastric effects of qat. It causes stomach trouble and makes the consumer puzzled. Qedan [36] found about 40 components in the essential oil distilled from qat, e.g. ocimene, B-phellandrene, terpinolene, a- and B-pinene, nerol, linalool, a-terpineol.

The effects produced by chewing the fresh leaves of qat are described as similar to those produced by an amphetamine or amphetamine-like stimulant, only more pleasant and agreeable when not used in excess. Qat is also an appetite suppressant. Chewers in rural areas use the leaves to give them energy to work and in urban areas users chew qat as a pass-time stimulant, or as a study aid [24]. It is said that qat dilate the pupil of the eyes and to excite the whole of the central nervous system. Abdel Sattar [37] isolated tingnone and 22-hydroxytengnone from the callus of qat leaves grown in greenhouse. 22-hydroxytengnone exhibited significant cytotoxic activities against leukemia (ED50 0.54 µg/µ) and prostate cancer (ED50 4.4 µg/ml). Tingnone was also shown to exhibit strong non-selective broad cytotoxicity against cancer.

4. Results

4.1. Vegetation analysis

Several species were found to occur with *C. edulis* cultivation in Yemen (Table 1). Considering the studied 12 sites in the different districts in Yemen mountains, only three species were found to co-exist with qat at more than 60% presence. Those species were *Solanum nigrum*, *Convolvulus arvensis* and *Amaranthus sp.* Ten species were found to occur with qat at presence value 41–60%, eleven species occurred at presence 21–40% and forty nine species were recorded with qat at presence value less than 20% (Table 1).

Three groups of stands are similar in terms of their vegetation are objectively identified by the two-way indicator species analysis program (TWINSPAN), at level 2 of classification. The indicator species of each group are identified.

Group A includes one stand only (no.1) and has *Ammi visnaga* as an indicator species. **Group B** is formed from seven stands (no. 2,6,10,11,12,7&8). It has three indicator species *C. edulis*, *C. arvensis* and *Euphorbia sp.*

Group C includes four stands (no. 3,4,5&9) with *Corchorus olitorius* and *Heliotropium longiflorum* as indicator species.

The ordination diagram provided by the first axes of canonical correspondence analysis is shown in Fig. 1. This diagram consists of three sets of points including sites (points) species (windows) and environmental variables (arrows) which display the sites-species-environment relationships.

The diagram shows that the species of group C (*C. olitorius* and *H. longiflorum*) are occupying the bottom left side of the diagram. These species occur in relatively saline habitats (with high EC, TSS, CL and Na). Similar comparisons make it clear that *A. visnaga*, the indicator species of group A, is highly

Table 1 – Species associated with *Catha edulis* at 12 sites represented the different habitats in Yemen. * < 20% presence with qat, **21–40% presence with qat, *41 60% presence with qat, **** > 60% presence with qat.**

<i>Acacia eherenbergiana</i> *	<i>Fagonia taechholmiana</i> *
<i>Acacia gerrardii</i> *	<i>Flaveria trinervia</i> **
<i>Acacia italica</i> *	<i>Forsskalea tenacissima</i> **
<i>Aerva javanica</i> *	<i>Francoeuria crispa</i> **
<i>Alternanthera pungens</i> *	<i>Genaphalium leuto-album</i>
<i>Amaranthus sylvestris</i> *	<i>Grewia tenax</i> *
<i>Amaranthus spp.</i> ****	<i>Heliotrobium bacciferum</i> ****
<i>Ammi visaga</i> *	<i>Heliotrobium supinum</i> *
<i>Anastatica heirochuntica</i> *	<i>Heliotropium Longiflorum</i> **
<i>Apium nodiflorum</i> *	<i>Hibiscus trionum</i> *
<i>Argemone Mexicana</i> *	<i>Indigofera spinosa</i> *
<i>Arnebia hispidisema</i> *	<i>Kickxia aegyptiaca</i> *
<i>Asparogus Africana</i> *	<i>Lamarchia aurea</i> *
<i>Bidens bipinnata</i> ***	<i>Lavandula pubescens</i> *
<i>Boerhaevia diffusa</i> ***	<i>Malva parviflora</i> **
<i>Chenopodium album</i> *	<i>Marobium vulgare</i> *
<i>Chenopodium murale</i> ***	<i>Medicago sp.</i> *
<i>Chenopodium schranum</i> **	<i>Orthosiphon pallidus</i> *
<i>Corchorus olitorius</i> *	<i>Peganum harmala</i> *
<i>Cleome Africana</i> *	<i>Pergularia tomentosa</i> *
<i>Commelina forsskalea</i> *	<i>Plantago Lanceolata</i> **
<i>Contoneaster racemiflora</i> *	<i>Plantago major</i> **
<i>Convolvulus arvensis</i> ****	<i>Reichardia tingitana</i> **8
<i>Conyza dioscoridis</i> *	<i>Reseda muricata</i> *
<i>Conyza Linifolia</i> ***	<i>Ricinus communis</i> *
<i>Cornulaca monocantha</i> *	<i>Rumex</i> *
<i>Cynodon dactylon</i> *	<i>Schinus molle</i> *
<i>Datura stramonium</i> *	<i>Solanum albicaule</i> *
<i>Digera muricata</i> *	<i>Solanum nigrum</i> ****
<i>Dploxis erucoids</i> ***	<i>Solanum unguiculatum</i> *
<i>Echinops spinosissimus</i> *	<i>Sonchus oleraceus</i> *
<i>Eragrostis ciliaris</i> **	<i>Tagetes minuta</i> *
<i>Eragrostis pilosa</i> **	<i>Tamarix nilotica</i> *
<i>Euphorbia peplis</i> ***	<i>Tribulus terrestris</i> *
<i>Fagonia Africa</i> *	<i>Withania somnifera</i> ***
<i>Fagonia Arabica</i> *	<i>Xanthium spinosum</i> ***
<i>Fagonia cretica</i> **	

correlated along the gradient of HCO₃, Mg and water holding capacity of the soil.

4.2. Soil and irrigation-water properties

Soils in mountains occupied by qat cultivation are rich in fine particles (silt + clay), particularly at lower altitudes (Table 2a). The percentage of clay ranged between 15.7% at 1700 m.a.s.l. and 1.9% at 2500 m.a.s.l. The moisture content was relatively high (19.8%) at lower altitude (1500 m.a.s.l.), and low (8.6%) at high altitude (2500 m.a.s.l.). The soils were slightly alkaline (7.45–8.03). The range of electric conductivity varied between 316 and 441 µS/cm. The content of soluble bicarbonates varied between 0.33 and 0.61%. Sulphates varied significantly at different altitudes. It was relatively low at high altitudes (1.16–1.56%). The values of Na and Mg showed no significant variation in relation to the different altitudes. Potassium and Ca ion concentration varied significantly in relation to altitude levels. The irrigation water characteristics at different altitudes are shown in Table 3. The water is slightly alkaline (pH = 7.91 ± 0.28), rich in SO₄ (72.99 ± 24.36 mg/l), Na (57.6 ± 8.21 mg/l), Mg (37.61 ± 16.81 mg/l) and Ca

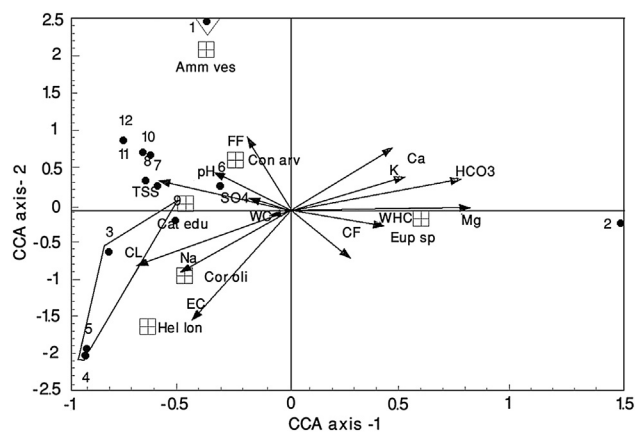


Fig. 1 – Canonical Correspondence Analysis (CCA) ordination of sites dominated by *Catha edulis* along the gradient of 14 soil variables 12. The soil variables are abbreviated as follow: FF = fine fraction, CF = coarse fraction, CL = chlorides, Na = sodium, Ca = calcium, Mg = magnesium, CO₃ = carbonates, HCO₃ = bicarbonates, EC = electrical conductivity, SO₄ = sulfate, WC = water content, WHC = water holding capacity, TSS = total soluble salts, pH = soil reaction. The indicator species names are abbreviated to the first three letters of the genus and species names respectively. For full species names see Table 1.

(34.11 ± 14.41 mg/l). Water pH was highly positively correlated with altitude ($p < 0.001$), but water salinity (EC), TSS, CL, SO₄ and Mg ion content were highly negatively correlated with altitude ($p < 0.001$). The number of species associated with qat

showed low negative correlation ($p < 0.05$) with CO₃ content and low positive correlation ($p < 0.05$) with K ion content in irrigation water.

4.3. Leaf anatomy

The chewing leaf thickness at middle part was relatively higher at high altitude (805–825 μm). On the other hand, the leaf thickness at its ends was lower at high altitude (225–272 μm). The epidermal cell thickness varied significantly in relation to altitude. It was relatively higher at high altitude. The spongy parenchyma tissue showed no significant variation at different altitudes. However, palisade parenchyma varied significantly at different altitudes (Table 2b).

4.4. Plant-environment relationships

Seven environmental variables were found to have significant effect on chewing leaf area (CLA), proline content of CLA, TN of chewing leaves and TN of non-chewing leaves (Table 4). Air temperature and rainfall were significantly positively related to CLA and proline ($p < 0.01$), and the electrical conductivity of the soil ($p < 0.05$). Elevation showed negative significant effect on CLA ($p < 0.05$) and proline ($p < 0.05$). Water holding capacity and bicarbonate content of the soil showed negative significant effect on the TN of non-chewing leaves. The moisture content of the soil increased the TN of chewing leaves ($p < 0.05$). The thickness of spongy tissue of chewing leaves was highly positively related to the percentage of clay in the soil ($p < 0.001$). Soil moisture content had negative significant effect on the leaf thickness at its ends ($p < 0.01$), epidermal cells ($p < 0.05$) and spongy tissue of the leaf ($p < 0.05$).

Table 2 – a) Physical and chemical properties of soil samples collected from 6 selected sites of *Catha edulis* farms at different levels of mountains and b) the thickness of chewing leaves at different altitudes in mountains of Yemen. Each value represents an average of 4 samples from each site. Means followed by the same letter do not differ significantly at $p < 0.05$ level of significance.

Sites	1	2	3	4	5	6
a) Soil						
Elevation (m)	1500	1700	1900	2100	2300	2500
Clay (%)	10.30a	15.70b	9.80a	8.90a	8.60a	1.90c
Silt	11.90a	12.10a	12.20a	11.50a	12.10a	2.40b
MC	19.80a	10.20b	8.20b	20.30a	16.80a	8.60c
WHC	61.90a	57.30a	59.80a	61.50a	75.70b	47.90c
HCO ₃	0.34a	0.61b	0.33a	0.40a	0.52b	0.45a
SO ₄	4.11a	3.89a	3.24a	3.31a	1.56b	1.16b
pH	7.61a	7.62a	8.03b	7.45a	7.71a	7.64a
EC (μS/cm)	339.00a	316.00a	326.00a	441.00b	339.00a	326.00a
Na mg/100 g soil	4.70a	4.13a	3.90a	4.63a	4.62a	4.81a
K	0.83a	0.90a	0.84a	0.27b	0.39b	0.12b
Ca	3.91a	4.36a	4.48a	1.81b	1.51b	1.29b
Mg	1.53a	1.57a	1.42a	1.61a	1.45a	1.31a
b) Chewing leaves thickness (μm)						
Middle part	760.00a	770.00a	780.00a	780.00a	805.00b	825.00b
Ends	317.00a	330.00a	324.00a	253.00b	265.00b	272.00b
Epidermal cells	8.50a	10.20a	9.40a	8.30a	13.50b	15.00b
Palisade parenchyma	79.00a	86.30a	110.50b	109.30b	103.80b	105.00b
Spongy parenchyma	125.00a	122.00a	131.30a	138.80a	127.50a	135.00a

5. Discussion

Since ancient times man has been aware of the properties of plants. The knowledge that he had of these properties enabled him to combat and resist as much as possible the harshness of nature. Thus, he had resource to certain plants to heal, to lose pain or to relieve hunger, in short to survive. Later on, the progress of science led him to isolate and to extract the active constituents of the plant that he knew to be psychoactive. On account of the benefit that they were able to take and feeling of the well being that they imported, these were quickly diverted from their original purpose. They were thus used for purposes that were no longer medical. In this way, abusive and wrong use of such plants made its appearance [38].

Life appears to some people to be hostile, unjust or oppressive and psychoactive substance, in other words drugs, constitute the best refuge, the means of release and escape. Drugs, they believe, will provide them with a means of expression. But, they deluded themselves, for drugs end up by enslaving them to the extent of turning them late living organisms that society rejects. This is the case of all drug addicts all over the world, however, the case is not the same in Yemen as well as in some countries of East Africa, Kenya, Ethiopia, Eritrea etc, where large number of people, unfortunately, do believe that qat is not a serious drug and chewing of its leaves, has no bad impacts on their health.

Al-Thani [1] reported that qat was the subject of scientific interests since antiquity particularly during ancient Greeks. He added that Alexander the Great ordered his army to use its leaves as a medicine to prevent epidemics against apathy and melancholy (Sadness). Morghem and Rufat [26] mentioned that qat consumption is a habit like tea or coffee but not an addiction likes hashish and opium or other serious drugs. They added “this does not mean that qat is not harmful” Al-Meshal [39] stated “due to qat’s habit forming properties, it has been classified as a substance of abuse by WHO”.

Qat was first introduced to Yemen from Ethiopia between the first and sixth centuries. Thence, qat cultivator spread

widely replacing the cultivation of coffee trees which has been almost destroyed completely except of few trees hidden between the thick vegetation of qat. More than 97% of qat production of leaves is being consumed locally in Yemen. This, definitely has bad impact on the economy of Yemen which used to export its high qualities coffee seeds abroad.

Characteristics of habitats suitable for qat can be predicted from the results of the present study. Sites favorable for qat have rich fine particles (silt + clay), high moisture content (8.6–19.8%) and slightly alkaline (pH ranged from 7.45 to 8.03). Occupied soils are less saline (EC ranged from 0.316 to 0.441 mS/cm). Habitat occupied by qat also supports several other characteristic species. The most common species associated with qat include *S. nigrum*, *C. arvensis* and *Amarnthus* sp.

Hill [35] and Gethum and Krikorian [40] reported that there are obvious difference in the morphology and chemical constituents of qat grown in different areas. These differences may be due to its cultivation over countries under different environmental condition (altitudes, soil, temperature, rainfall, humidity, properties of irrigation water, etc.). Local tradition of cultivation may have also certain effects on the growth farm and chemical constituents of qat plants. In Yemen there is only one species of qat (*C. edulis*) which grows in red or white shrubs without real variety differences. Ramadan [19] recognized forty kinds of qat shrubs based on geographical distribution and altitudinal origins. All of these ecotypes though belong to one species (*C. edulis*) yet not identical morphologically and the extracts of the chewing leaves, show great different effects on the consumers. Accordingly, the price of qat leaves collected from trees grown on high altitudes may have price 10–20 times more than similar bunch collected from qat cultivated at lower altitudes. The CLA was relatively higher at high altitude (805–825 μm). Also, the epidermal cell thickness was relatively higher at high altitudes (Table 2b).

A question may be raised: could qat plant, the flower of paradise as they call it in Yemen, be a useful friend and its present wide cultivation be profitable crop to Yemen people or it will still a harmful enemy (or foe plant) for unknown period? The answer of this question is very important to the future of Yemeni and other West African countries where qat is naturally growing and/or cultivated covering vast areas of their mountains.

His Al might the God said “Verily all things have been created in proportion and measure” (Surat Al Qamer, verse No. 49, chapter No. 54). “All plants even those regarded as disadvantageous pests may have some use” [41]. It is well known that most of our essential requirements (food, clothes, fodder for domestic animals, medicines, houses, furniture, paper, etc.) are taken from different parts of plants (fruits, seeds, flowers, leaves, shoots, roots, etc.). In the same time certain harmful things e.g. all drugs like opium, hashish etc. and alcoholics like wine, whiskies etc. are also produced from plant parts. This means that man can use the plants either for his benefit or for his harm. For example, grapes, dates, apple and pomegranate are very useful and delicious fruits. However, man, by his stupid choice, used these fruits to produce harmful alcoholics. This can be applied also on qat plants, which has certainly

Table 3 – Means \pm SE of water characteristics (mg/l) used in the irrigation of qat at different altitudes in Yemen. The correlation coefficient between the irrigation water parameters with species richness and altitudes are shown. * $p < 0.05$, ** $p < 0.01$, * $p < 0.001$.**

Water parameter	Species richness	Altitude	Mean	\pm SE
Altitude m a.s.l.	-0.12	1	1971.33	99.57
pH	-0.23	0.81***	7.91	0.28
EC mS/cm	0.12	-0.96***	9.58	5.33
TSS	0.23	-0.94***	2.67	1.73
HCO ₃	0.29	-0.66***	14.41	5.07
Cl	0.27	-0.87***	11.29	7.64
CO ₃	-0.53*	-0.41	3.08	1.69
SO ₄	0.21	-0.88***	72.99	24.36
Na	0.13	-0.61*	57.6	8.21
K	0.53*	-0.34	8.03	3.82
Ca	0.49	-0.57*	34.11	14.41
Mg	0.22	-0.84***	37.61	16.81

Table 4 – Pearson correlation coefficient between A-Chewing leaf area (CLA), non-chewing leaf area (non-CLA), proline of CLA, total nitrogen of CLA and non-CLA with some environmental variables. B- Anatomical characteristics of the chewing leaves e.g. leaf thickness at middle, ends, epidermal cells, palisade and spongy parenchyma with the studied environmental variables. * $p < 0.05$, ** $p < 0.01$, * $p < 0.001$.**

A) Soil	CLA	Non-CLA	Proline	T.N. of CLA	T.N. of non-CLA
Moisture content	0.297	-0.329	0.072	0.632*	-0.192
W.H.C.	0.475	-0.031	0.322	0.467	-0.618*
Elevation	-0.696*	-0.215	-0.612*	0.184	0.109
Temperature	0.788**	0.096	0.728**	-0.261	0.007
Rainfall	0.793**	0.095	0.699**	-0.125	-0.117
EC	0.684*	-0.191	0.674*	-0.176	-0.095
HCO ₃	-0.003	0.166	0.073	0.092	-0.649*
B) Chewing leaf thickness at	Middle	Ends	Epidermis	Palisade P.	Spongy parenchyma
Clay	0.021	0.391	0.400	0.178	0.840***
Moisture content	-0.469	-0.722**	-0.710*	-0.406	-0.590*
W.H.C.	-0.308	-0.736**	-0.659*	-0.653*	-0.376
K	-0.009	0.087	0.367	-0.016	0.650*

certain useful uses. As mentioned before, more than 95% of the Yemeni population are chewing qat's leaves, i.e. using it from its harmful side without thinking that it is also a beneficial plants.

Regarding qat cultivation in Yemen, Yemeni people may be classified under three main sectors: 1-qat farmers, 2-qat merchants and 3-qat consumers. The farmers and consumers of qat are the richest Yemeni people who represent less than 5% of the total population. Most of them are also qat consumers, which comprises men and women, rich and poor and young and old persons. All do believe that they cannot live in good state without chewing qat leaves daily. They do believe also that such strong desire (chewing qat leaves) is not as addiction but it is a bad habit like smoking cigarettes. It became very difficult, or even impossible, to convince them to change their believes particularly when the Muslim Yemeni leaders (Sheiks) are also enjoying chewing qat leaves. Qat cultivation in Yemen is, thus, more than a traditional or conventional, high profitable crop and it is unwise to ask them to replace it with coffee low profitable cultivation.

Since about century coffee cultivation was representing the backbone of the Yemeni economy. The yield of this crop was exporting abroad. On the other hand, the major part (>97%) of the yield of qat's leaves is consumed inside the country, very small part being exported mainly for the use of Yemeni people living outside Yemen. The problem become even worse when we known that the farmers of qat may collect leaf crops 3-4 times/year whereas coffee tree produces only one seed-crop/year. Both farmers and merchants, most of them are decision-makers in Yemen, will strongly refuse any proposal aiming at the revival of coffee tree cultivation in Yemen on the expense of qat cultivation.

6. Conclusion

Several publications showed that qat plant is rich in chemical constituents that make it a very valuable renewable resource in drug industry. These include: [4,5,20,28-33,36,37,42-49].

Our proposal is to make use of the excellent experience of the Yemeni people in qat cultivation and encourage them to extend areas cultivated by high quality qat. The yield of qat

leaves will be used as raw material to run drug factories to be established in Yemen. To overcome the competition with the merchants of qat who buy its leaves from the farmers, the factories should pay high price (5-10 times more than that price paid by the merchants). Qat's price for chewing will be, thus, very high and most people will not be able to purchase it. Gradually, the number of people chewing qat will decrease. This proposal might take a long period to combat the acute problem of qat addiction in Yemen, but it may be the only feasible solution for using qat from its beneficial side as a renewable cultivated raw material in drug industry. This means that qat will be of agricultural, industrial and social benefits instead of being harmful foe plant.

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