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Cactus (*Opuntia Ficus Indica*) and its role in poverty reduction and achievements of goals of the Ethiopian green economy: A review

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Abstract
The increase of the world population and change in climatic conditions lead to the drought and shortages of food will happened in the most countries of the world. In Ethiopia, most of the time affected by drought and this is because about 60% of the country is dryland and in these parts of the country annual rainfall is low and seasonal and inter-annual variability is high. Thus, given attention to the drought resistance plant resources will decrease the risks. Cactus is a drought-resistant plant and it has the potential to mitigate the climate, environment and secure the food and feed for humans and animals respectively. Cactus pear which is known as "Beles"/" Quliqualabhri" in Tigray northern Ethiopia, is adapted to drought areas of the region and is used as feed, food, fence, and source of income to secure in both food and nutrient. The objective of this review paper was to show the role of cactus in climate-resilient, food security, energy, and pharmaceutical to achieve goals of the Ethiopian green economy; to declare the challenges in utilization and development of cactus -based Agri-business and to forward its future perspectives endorsements and elucidations. Hence, the cactus pear is strategic and has a potential advantage of carbon sequestration, promoting renewables energy, bio-material development and food, pharmaceutical and cosmetic industries. However, this crucial wild plant is given little attention in research and development, having a lack of postharvest handling technologies and facilities as well as invasion of cochineal pests are serious challenges in the utilization and development of cactus pear. Therefore, it is important to have a postharvest technologies and facilities, high qualified cactus base researchers and professionals and rethinking and looking over the cochineal pest and its damage are best future perspective solutions to achieve goals of Ethiopian green economy and to have an effective reduction of food poverty.

Keywords: cactus pear, cactus role, green economy, food poverty, challenges

1. Introduction

The World population is expected to reach 10.5 billion by 2050, which further adding concerns to global food security by 60% to meet the demand in the predicted years [1]. Otherwise, Overweight, obesity and diet-related chronic diseases are no longer symptoms of wealth and abundance but are increasing in every region and most rapidly in low- and middle-income countries [2]. According to the recent UN report of 2019, 250 Million people of Africa are classed as hunger as a result of climate change and population growth in the world [3].

In Ethiopia, the food poverty index rate in 2015 showed that 33.6% and in terms of regional distribution the food poverty rate index in the Tigray region in the same year was 37.1% [4]. Thus, given attention to the natural resources which have the ability to resist drought and mitigate climate change to secure both environment and food is much intended [5]. Cactus pear is the food for the future this is because of its nutritive value, its accessibility, its flavor and its low impact on the environment [6]. Moreover, given the environmental changes under-way, the cactus pear could be considered an option as a carbon sink, absorbing and holding excess CO2 in areas where the plant can be established but where nothing else will grow [7]. Opuntia spp. originated in the tropical and subtropical Americas and, wild or cultivated, they can be found in a wide variety of agro-climatic conditions across the entire American continent [4, 8]. The plant has spread further carried by people as they traded and settled to Africa, Asia, Europe, and Australia, where the cultivated and wild plants continue to provide food and materials [8].

Opuntia spp have been known by different names in the various countries of the world where it is found. For instance, in Spanish chumbera, in Italy fico d'India, France as figue de Barbarie, Australia, South Africa, and the United States, like prickly pear. Israel is known as sabras. In Eritrea and Ethiopia, it is called Beles and in Brazil, it is known as Palma forrageira, etc [7].

Opuntia ficus-indica is the cactus species of greatest agronomic importance, due to its delicious fruits, but also is used as fodder for livestock or as a food for human consumption, for Bio-energy, Bio-material, Soil and water conservation, Pharmaceutical and cosmetics, Climate change Mitigations [5].

However the plant has various applications there is no emphasis on it by the government of Ethiopia as well as the peoples, scholars, investors and businessman's [4].

This review focuses on the roles of cactus (opuntia indica ficus) in climate mitigation, food poverty reduction, promoting bio-energy and bio-material, pharmaceutical and cosmetics industries which are lead to achieve goals of Ethiopian green economy. It also explained the challenges in the utilization and development of cactus-based agri-business enterprises. In addition, the author suggested future perspectives on how cactus would be utilized and developed to reduce food poverty in Ethiopian communities.

2. Methodology

The review article was develop using primary and secondary data collection. While the primary information was collected through key informant discussion, field observations and practical experiences, the secondary data was collected from published and unpublished materials.

2.1 Role of Cactus (*Opuntia ficus-indica*) in Climate Change and Environment

Over the last four decades, it has become evident that rising atmospheric CO_2 from fossil fuel consumption is causing increased climate variability [5]. This leads to important issues associated with global warming and modified continental patterns of precipitation that are already having significant effects on species distribution and function in the plant biosphere [7].In comparison with other plants, Crassulacean Acid Metabolism (CAM) plants (agaves and cacti) can use water much more efficiently with regard to CO_2 uptake and productivity [9]. Biomass generation per unit of water is on average 5-10 times greater than in other plants [10]. Various experiments in different regions have been carried out to quantify the carbon sequestration potential of Opuntia. The total daily net CO_2 uptake was 393 mmol m^{-2} averaged over five measurement dates, and annual CO_2 uptake was 144 mol m–2 [24]. Cactus has a great role in carbon fixation (climate change) and protecting the environment [7]. According to many pieces of research, given the specific phonological, physiological and structural adaptations of cactus, it can be assessed that it is well-positioned to cope with future global climate change [8]. Moreover, it can conserve both soil and water [7].

In Ethiopia, drought frequently occurs and is an extreme weather event. 60% of the country is dryland and in these parts of the country annual rainfall is low and seasonal and inter-annual variability is high. These areas are highly vulnerable to desertification and droughts have been persistent throughout history [12].

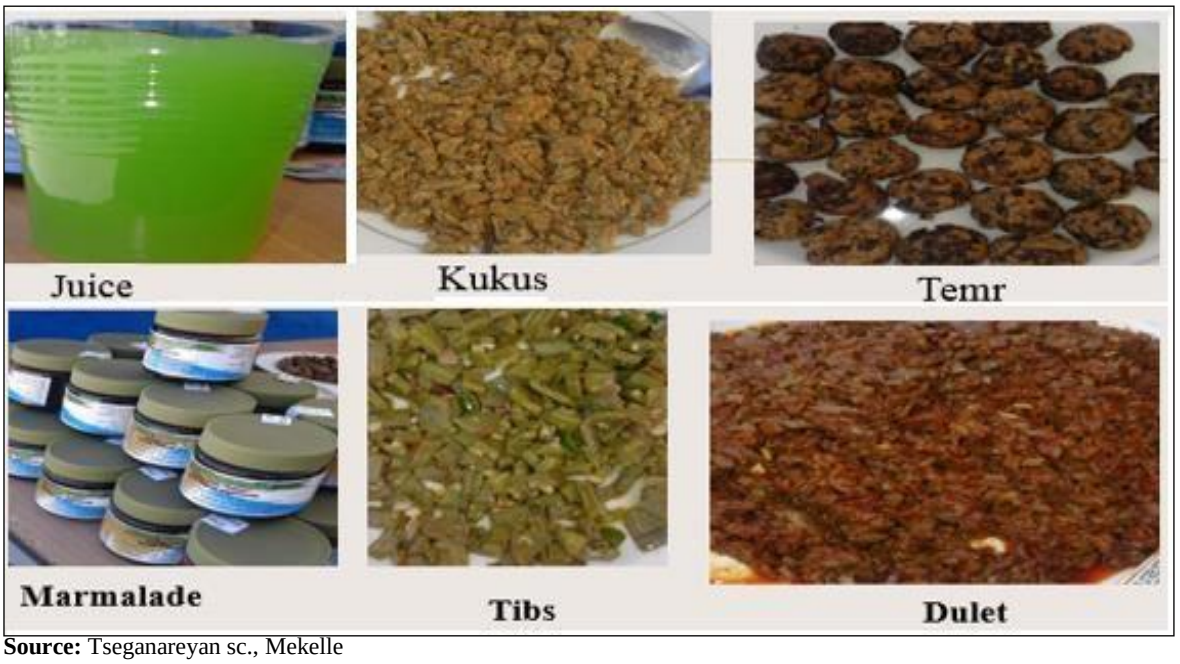
Thus, cactus is a very great plant which used to mitigate the climate conditions because of the unique characteristics of its anatomy and morphology, which have enabled it to adapt to many highly stressful growing conditions, meaning that the plant can be a viable option in regions where other plants will not survive [7].

2.2 Role of Cactus in Food and Beverage Industries

Natural products and health foods have recently received a lot of attention both by health professionals and the common population for improving overall well-being, as well as in the prevention of diseases [13]. The great number of potentially active nutrients and their multifunctional properties make cactus pear (*Opuntia spp.*) fruits and cladodes perfect candidates for the production of health-promoting food and food supplements [14]. It is rich in carbohydrates, minerals, and vitamins [15]. In different countries of the world the plant used as fresh and processed products such as juice, marmalade, jam, wine, dried products, etc [16]. Besides, food for humans, it also serves as feed for animals in arid and semi-arid countries [17].

In Ethiopia, mainly Tigray the Cactus fruit/Beles is unique because of its flavor, moisture content, and its pulp percentage and weight. While the average Beles fruit weight is 140-147gm, in Mexico commercial fruit weight is ranged from 67-216gm [15]. The total soluble solids (TSS) in Ethiopia is ranged from 13.5 to 16.5 ºBrix, whereas in Mexico it is ranged in between 14 to 15 ºBrix, Italy 13-15; Argentina 12-15; USA 10-14; Israel 14 ºBrix respectively. The seed weight per single fruit (1.52gm) in Ethiopia lower than in Mexico (5.2gm). The seed number in Chilean 1320 in turkey 227 to 270 and in Ethiopia 97 to 353 per single fruit respectively [15]. The Titrable acidity content in Ethiopia Cactus fruit (0.056-0.13 %) is lower than in Mexico (0.06- 0.2%) and it has a direct effect on the flavor of the fruit [15].

Here as shown in the figure below (Fig2) small and micro enterprises in Northern Ethiopia; Tigray has been working in processing value-adding cactus products but, they face challenges adequate market because of them having a lack of processing, packaging materials and market chain [4].



Source: Tseganareyan sc., Mekelle

Fig 1: Value-added food products from cactus cladode, fruit, and peel in Tigray, Northern Ethiopia.

2.3 Role of Cactus in Pharmaceuticals and Cosmetics Industries

The cactus-based products used as functional foods or supplementary foods and which can be produced from the cactus pad to control diabetes, cholesterol, gastrointestinal ills and obesity [14]. Besides, it has an anti-cancer effect, anti-inflammatory effect, anti-hyperlipidemic and anti-hypercholesterolemic effects [8]. The effects of cactus are generally attributed to the high fiber content of the cladodes, although other active ingredients (such as beta-carotene, vitamin E and beta-sitosterol) may be involved [15].

It also used to produce natural cosmetics products such as shampoos, creams, soap, conditioner, gel, astringent lotion with different brands respectively [16]. Although the cosmetics industries do not require large amounts of cactus, they have to be produced different cactus based cosmetic products in large scale and then small cactus producers are benefited [8, 16].

2.4 Role of Cactus in Bio-Energy and Bio-Materials

Plants with Crassulacean Acid Metabolism (CAM), such as *Opuntia ficus-indica*. Mill, ARE recommended as alternative energy sources, given their high potential for biomass production [7, 18].

An anaerobic process where the biodegradable material is transformed by biochemical reduction and produces a combustible gaseous mixture called biogas. Cladodes with animal manure at pH value of neutral or basic get biogas rich in methane, otherwise biogas rich in CO2 [10].

Electrical Research Institute (ERI) in 2010 Report, the Mexico produces Biogas from cactus to promote renewable energy, the law of climate change. $40M/118,300ton/year $216-401/ton and 207ton/ha/year cactus produced through irrigation [10]. Besides, Wayland Morales (Chilean), head of Elqui Global Energy argues that 'an 0.40 ha (82ton) of cactus produces 43 200 m^3 of biogas or the equivalent in energy terms to 25,000 liters of diesel [9]. Besides, developing Bio-materials such as handcraft and shopping bags from cactus also possible and they are ecofriendly and biodegradable products [16]. In general, the cactus plant is the bridge of life to peoples who lived in rural areas used as food for human for about five to six months and feed for the animal throughout the year and, income generation, etc. However it is a unique resource, it does not commercialized and utilize effectively. [4, 19].

3. Challenges in cactus (*Opuntia ficus-indica)*, "Beles" development and utilizations

Even though the cactus (*Opuntia ficus-indica)* has a lot of advantages, there is a challenge to better utilize and develop this big Ethiopian resource. Some of the challenges are explained and presented in the paper.

3.1 Little attention in Research and Development

The cactus pear in northern part of Ethiopia mainly Tigray region covers more than 379,338 hectares of land, i.e., 7.4% of the total land of the region and then the people of the area directly or indirectly depends on the wide range of its products like food, feed and soil conservation, and traditional medicines, this miracle plant is given little attention in its community-based research and development [4].

3.2 Lack of technologies (Production, Processing, and Marketing).

However, the cactus pear is rich in nutrient and production potential, it would not explore the world market because of lack of post-harvest, processing and distribution technologies. Besides, due to having a lack of improved varieties, production techniques and processing technologies contribute to challenges in exploiting the market to the fullest are challenges of this plant in Tigray [4].

Although cactus pear is an essential plant for advancing the Scio-economic value of the people, the community is not on the right track in exploiting the potential of the plant. Surprisingly, the contribution that farmers are currently gaining from cactus is with zero cultivation practice. The agronomic techniques (harvesting, transporting and storing) are very traditional [4, 16].

3.3 Lack of Strong collaborations among stakeholders

The cactus plant is very important to arid and semiarid zones of Northern Ethiopia mainly Tigray it is a "bridge life. So that it is indispensable to commercialize and promoting the products through having a strong collaboration and supports among stakeholders and this leads to industrialization which is significant in cactus utilization and development [16].

3.4 Invasions of cochineal pest

Cochineal insects are harvested from prickly pear plantations in Peru, Chile, and Mexico. Cochineal extract is a natural dye extracted from female costa cochineal insects [7]. This dye is used fully for different coloring purposes, foodstuff, cosmetics and pharmaceuticals [20]. Even though insects are beneficial, they become a serious problem to the cactus plant of Tigray and it disturbing in uncontrolled situations [20]. It is also important to have well-designed management strategies to ensure cactus pear survival [21]. In the figure below (Fig3) showed how the cochineal pest damages the *opuntia ficus Indica* plant in northern Ethiopia, Tigray region.

a b c

Fig 3: Photo a, b, c *Opuntia Indica L.* cactus infested by cochineal, dried and deforested respectively.

According to Ethiopia's climate-resilient green economy, the strategy is built up with four pillars mainly 1) improving crop and livestock production practices for higher food security and farmer income while reducing emissions; 2) Protecting and re-establishing forests for their economic and ecosystem services, including as carbon stocks; 3) Expanding electricity generation from renewable sources of energy for domestic and regional markets and 4) Leapfrogging to modern and energy-efficient technologies in transport, industrial sectors, and buildings [12]. Thus, the Ethiopian government is expected to promote the role of cactus in achieving the goals of a green economy through having the following strategies.

4. Future perspective strategies to achieve goals of Ethiopian green economy and poverty reduction

4.1 Producing high Cactus based researchers and professionals

In Mexico, there is a university that engages in cactus-based research and development and its result and outputs transfer in technology to give benefit to society [6, 10, 16]. Now, the country is leading in the utilization and development of the plant. Thus, here in Ethiopia also give attention to the resources by producing professionals and conducting research and development activities to meet the goals of a green economy.

4.2 Emerging strong post-harvest technologies and quality management system

The post-harvest loss of agricultural food products in developing countries is very high, for instance, post-harvest loss of fruits and vegetables in Ethiopia 50% produce is lost due to lack of appropriate handling, storage, transport, and packaging [8, 16, 22]. Thus, emerging post-harvest technologies and having a quality management system in cactus pear fruit is very important to penetrate the global market as well as to reduce losses. Hence, to have a successful quality management system, it should have a strong collaboration among respective stakeholders. As a result, the product will be certified and it can penetrate the global market, finally, the product would contribute to achieving the goals of the Ethiopian green economy.

4.3 Rethinking and looking on Cochineal pest invasions

Even though the cochineal pest has various commercial advantages such as or cosmetic, pharmaceutical, textile and food industries for coloring, it is an enemy of Ethiopian mainly Tigray cactus plant and it damages huge potential areas of the regions [8, 20]. However various research work is conducted by different researchers, they are not efficient and effective. Thus, rethinking and give attention to this pest by all respective bodies is very important to emerging good ideas and solutions.

5. Conclusions

Cactus pear (Beles) is a perennial succulent plant which is characterized by drought resistance, this is due to its morphological, physiological and anatomical characteristics. It is described as a “Wonder plant, a green gold vegetative world, and a bridge of life” because of its huge economic contribution to the livelihoods of smallholder farmers and provides agronomic and environmental importance to mitigate the effect of climate change and important to soil and water conservations. However, the crop productivity and utilization of the crop has been very limited because of different factors such as inappropriate cactus pear production and weak agronomic practices, high pre- and post-harvest losses that result in low productivity due to lack of technologies, poor or no research and extension on fruit, cladode and seed physiological, biochemical and morphological characteristics of the different landraces of the plant, poor market linkage nationally and internationally, cochineal infestation, and no enough diversified value added products. Therefore, strategies on having postharvest technologies and facilities, producing trained and high qualified cactus base researchers and professionals, and rethinking and looking over the cochineal pest managements are best future perspectives solutions to attain the described goals of Ethiopian green economy.

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