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Okra (Abelmoschus Esculents [L.] Moench) Research in Ethiopia and Achievements: A Comprehensive Review

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Abstract: ***Okra (Abelmoschus esculentus [L.] Moench) is an essential nutritional horticultural crop grown primarily in tropical and subtropical regions. It is cultivated mainly for food, as the most critical energy source and for medicinal uses in the tropics. In Ethiopia, oka is grown in some areas of North Western Ethiopia, with several advantages over other cereals as a food staple in areas with poor soil conditions, uncertain rainfall, and weak market infrastructure. Despite research on crop adaptability, selection, nutritional and anti-nutritional factors, there is a lack of information on the overall status, challenges, and the future role of Okra production in Ethiopia. This paper, therefore, provided a brief overview of genetic improvement, agronomic research, nutritional aspects, biochemical analysis, anti-nutritional factors, disease and insect pest management, and future research directions of Okra in Ethiopia. Moreover, genetic improvement, agronomic research, nutritional research, medicinal research, and anti-nutritional research. Different research findings have been obtained and registered since the inception of research on Okra in Ethiopia, including agronomic practices, crop protection technologies, and biochemical analyses of nutritional composition and anti-nutritional factors. The availability of these outputs in a compiled and comprehensive way is essential for enhancing the production and productivity of Okra in Ethiopia and to influence the policy makers to consider Okra underutilized crop not known by most of the country, enabling the introduction of scale-up to be known as one of the prominent food and nutrition security crops in the country. Hence, the article could serve as a helpful reference resource for researchers, students, agricultural extension workers, and NGOs working in Ethiopia on root and tuber crops in general and Okra in particular.***

Keywords: ***Breeding, Biochemical, Crop Protection, Food Security, Okr.***

Nomenclature:
EAA: Ethiopian Agricultural Agency
VEGF: Vascular Endothelial Growth Factor
PA: Phytic Acid
ANFs: Anti-Nutritional Factors
CG: Cyano Glycosides
IP6: Inositol Hexaphosphate

I. INTRODUCTION

Okra (Abelmoschus esculentus [L.] Moench) is an essential, underutilised horticultural crop cultivated predominantly in tropical and subtropical regions worldwide [38]. Okra is a horticultural crop that belongs to the Malvaceae family. It typically originated in northern Africa, including Ethiopia and Sudan. Okra, commonly known as "lady finger," is cultivated as a garden crop and on large commercial farms in Ethiopia. It is also called "ladyfinger" and is grown in both gardens and commercial farms. It is also cultivated well in hot weather, especially in regions with warm nights [20] [21]. The plant is valued not only as food but also for its medicinal properties. Its seeds are diuretic, and the leaves serve as nutritious cattle feed with therapeutic benefits [9]. Despite its importance, research on Okra cultivation and genetic diversity in Ethiopia has been limited, with little data on its production areas and productivity [27] [29]. Most Okra cultivation in Ethiopia depends on landraces, with limited exchange of genetic material between farmers, especially in the southwestern and western regions [39]. The fruit is rich in vitamins A, B, and C, as well as carbohydrates, fat, fibre, iron, and iodine, making it a key source of protein in many developing countries [4]. Various national institutions in Ethiopia, Ghana, Pakistan, and Nigeria maintain collections of Okra genetic resources [26]. In Ethiopia, Okra is cultivated mainly by small-scale farmers in lowland areas, including Tigray, Gambella, Benishangul Gumuz, and various parts of the Amhara region [27]. The plant is valued not only as food but also for its medicinal properties. Its seeds are diuretic, and the leaves serve as nutritious cattle feed with therapeutic benefits. Thus, generally, vegetables are colourful, vitamin-, mineral-, and fibre-rich foods. It has a significant medicinal value, mainly for humans. They are good sources of nutrients and also contain helpful phytochemicals and medicinal properties. Diversity in vegetable consumption increases benefits to consumers, as sources provide a vast and varied array of nutrients and phytochemicals. In Ethiopia, a lack of research and conservation has led to a call for urgent action to conserve Okra germplasm. Variability among okra genotypes is particularly underreported, with little reporting on okra genetic diversity [33]. Hence, this study was initiated to estimate the variability among okra accessions with respect to important qualitative and quantitative traits.

II. DESCRIPTION OF OKRA

Okra (Abelmoschus esculentus L., 2n = 130) is an allotetraploid derived from the natural hybridisation of a wild progenitor, A. tuberculatus (2n = 58), with another yet unidentified species with 2n = 72 chromosomes [16]. Okra is the most important

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vegetable crop, widely cultivated for its fresh, succulent pods [23] [41]. Okra is an autogamous species and predominantly a self-pollinating crop. Its tender green pod is the most economical and crucial constituent of vitamins A, B1, B3, B6, folic acid, C, and K, essential for the human diet [22]. Fresh, green immature okra pods are rich in protein, dietary fibre, unsaturated fatty acids, minerals, and vitamins essential to humans and can be consumed as vegetables [24]. Another benefit of okra fruit is its widespread use in the pickle industry. It is a source of important macro- and micronutrients such as calcium, potassium, zinc, and other minerals, which are often lacking in the diets of many developing countries [14]. Okra grains contain 22.14% protein, rare amino acids (such as lysine and tryptophan), fat, and fibre. Morphological and anatomical description of okra: the fruits, stem, and leaves of okra are covered with minute, soft, hairy structures. Although the flowers of okra are easily recognised by their slight yellowish colour with a crimson centre, they are highly dependent on various biotic and abiotic factors. The leaves of okra are polymorphous, characterized by hairy upper and lower surfaces, whereas the petioles are around 15 cm long. The edible part of okra or its capsule (pod) measures approximately 15–20 cm in length and has a pyramidal-oblong, pentagonal, hispid appearance—ties of vegetables to gain different components in the diet. However, despite the significant importance of Sub-Saharan Africa's global okra production, average crop yields are low and variable in the region due to a lack of improved, modern varieties. Okra is a drought-tolerant crop that can grow successfully under water-limited conditions with minimal supplemental irrigation. Despite being relatively drought-tolerant, the crop fails to reach its full yield potential, resulting in low marketable pod yields, particularly when drought stress occurs during the flowering and pod development stages. For example, 37 to 83% yield losses attributed to drought stress occurred during the reproductive stage [1]—the low yield was due to the cultivation of low-yielding and drought-sensitive varieties.

A. Agro-Ecology of Okra

Okra is adaptable mostly in an altitudinal range between in with an altitudinal range of -550m above sea level in the Gambela area to 650 m above sea level in the Benishangul Gumuz, it is grown better on the soil pH range from 6 to6.8, mean minimum and maximum temperatures of 18ºC and 35 ºC, respectively, and annual rainfall ranging from 900 to1,000mm. Okra is sensitive to extremely low temperatures and frost. The temperature requirement for normal growth and development is between 24°C and 28°C [6]. At 24°C, the first flower bud may appear in the third leaf axil, while at 28°C it may appear in the sixth leaf axil. A delay in time does not necessarily accompany this higher position, because at higher temperatures, the plants grow faster and reach the higher position earlier. For faster plant growth, higher temperatures help, though temperatures below 17 °C cause seed germination to fail, while temperatures above 42 °C cause flower buds to desiccate and yield losses in most cultivars. Temperature above 26 °C promotes better okra growth, especially in arid and semi-arid regions, when combined with warm night temperatures (>20 °C) [10].

In the present world, okra is the most heat- and drought-tolerant vegetable and can tolerate heavy clay soils and intermittent moisture, but the crop is vulnerable to frost, as it may harm pods [35]. The best-suited condition is a warm, humid growing period, but it can be successfully cultivated and well produced in hot, humid regions

III. IMPORTANCE OF OKRA

A. Okra is Used as a Food Crop

In Ethiopia, Okra is a vegetable crop widely consumed across the country for its multiple uses; its plant parts include the fresh leaves, buds, flowers, pods, and seeds. According to the current literature [25], okra is a vital vegetable widely cultivated for its pods and leaves. Moreover, its pod, chopped into small pieces, mixed with meat, can make delicious food. The other part is the smallholder farmer producing Okra for sale at the market, which will help cover household expenses, is an income-generating activity, and serves as a resource base for food conservation and disease treatment.

B. Economic and Social Importance

Okra vegetable and leaves for current use, and Okra seeds have played a significant role in social life, in which the roasted seed is ground, added to water, boiled, then drunk as coffee, which is a substantial source of income for growers.

IV. NUTRITIONAL VALUE OF OKRA

A. Okra Pod

Okra Seeds and pods contain a variety of phenolic compounds, including quercetin derivatives, catechin oligomers, and hydroxycinnamic derivatives. Okra, especially fresh pods, in addition to phenolic compounds, is rich in vitamin C (ascorbic acid) and (Beta carotene), which are antioxidants, also protective of cancer [42]. The fibre diet is advisable for diabetics, people with high blood pressure, and those with heart attack problems because it reduces sugar absorption, prevents hyperglycemia, and lowers cholesterol levels. Okra products are rich in insoluble and viscous fibres, which can reduce blood sugar and cholesterol levels [7].

The presence of microelements such as iron, zinc, manganese, and nickel in okra. And well represent the composition of numerous minerals such as Ca, K, Fe, Na, etc.

B. Okra Leaves

The leaves of Okra contain the most beneficial vitamins A, B, C, and K, as well as minerals such as Iron and Iodine.

It is an essential source of viscous fibre. Leaves are very rich in nutrients and phytochemicals. For all these contents, okra provides critical health benefits. In addition to nutrients, okra is known to contain antioxidants and fibre, which are beneficial to consumer health [40].

Okra leaves are the easiest source of protein because they can synthesise amino acids from a wide range of primary materials, such as water, carbon dioxide, and atmospheric nitrogen, as in legumes. Researchers [18] reported that the highest protein concentration is found in the leaves, which are used for both human and

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animal consumption, thereby making the young leaves a valuable source of nutrition.

V. SIGNIFICANT CHALLENGES AND OPPORTUNITIES OF OKRA PRODUCTION IN ETHIOPIA

A. Adoption Rate of Okra Production in Ethiopia

Significant challenges of Okra production in Ethiopia are low adoption rate, limited institutional structure, price escalation, and inefficiency in the feed market. Moreover, land shortage, the lack of planting materials (seed) and their high price, the absence of a reliable market for improved Okra seed, poor extension services, and recurrent drought are among the most critical impediments to okra production in Ethiopia. Cultivating Okra in farming communities is often overlooked, mainly due to a shortage of land for other crops. Grazing lands have been quickly converted to cropland to meet the demand of an ever-increasing human population. In Ethiopia**,** it has a significant medicinal value, mainly for treating humans. The low yield is due to the cultivation of low-yielding, drought-sensitive varieties. The crop exhibits extensive morphological variation for traits such as plant height, fresh pod length, number of days to 50% flowering and maturity, number of branches, number of pods per plant, and pod yield. The okra seed market is not encouraging producers, which could be associated with the high cost of initial seed and low demand for produced seed in the formal market. Okra research and development were limited to government and commercial large-scale farms, research centres, and universities. Low attention from government bodies and policymakers to Okra production and research is discouraging extension workers and researchers in the area. Poor productivity of okra after the farmer had expended many resources was another problem, and labour was also mentioned as the least-ranked challenge in okra production by the okra producers.

B. Opportunities of Okra Production in Ethiopia

Newly developed okra crops have a significant contribution to the well-being of smallholders, covering system development, resource and capability requirements, and governance implementation, which can be followed to produce a modified information system for livestock production and productivity improvement.

Adapting to climate change, climate-smart agriculture mainly includes intensification, which enables the inclusion of Okra crops and makes the shift from the current free-grazing system to an intensive cultivation system. Planting a few reports deal with aspects of the growth and yield of Okra in response to fertiliser solubilised in water used for drip irrigation may also be a wise method to avoid fertiliser loss [31]. The crucial role played by N is that it is the main component of amino acids. Amino acids form proteins and enzymes. Proteins contribute to crop body building, and enzymes catalyse biochemical reactions within the crop. Nitrogen also plays a role in chlorophyll, a molecule that helps the plant absorb energy from sunlight. Research has shown that Okra production can easily increase with higher soil nitrogen levels. It has also been demonstrated that Nitrogen combined with cropping spacing has improved crop growth and Okra pod production. Indeed, since Okra pods are rich in proteins, Nitrogen is definitely essential. Additional field investigations have demonstrated a positive impact of nitrogen fertiliser on fresh yields, plant height, fruit number per plant, and leaf number. The combination of Nitrogen and Phosphorus had no significant effect on plant growth and/or yield. Each nutrient plays its specific role and is not affected by the others. It was also found that the application of sufficient N at the right time has influenced cell division, foliage, and flowering density, as well as photosynthetic processes [37]. Ethiopian Agricultural Agency (EAA), the new sector established mainly for plant and animal regulatory systems, will take a significant leading role in variety development and resource cumulative conservation for forage crops, which is an encouraging fact for the era.

The recent ''YeLematTirufat'' initiative of the government is also an encouraging move for the Okra in general and the forage sector in particular. YelematTirufat development campaign focuses on nutritional opulence, which links farmers, pastoralists, and consumers.

VI. OKRA RESEARCH IN ETHIOPIA

Okra is one of the annual shrub crops, mainly grown in North Western Ethiopia, while in other parts of Ethiopia, it is not well known due to limited research. However, to improve across different agro-ecological locations, comprehensive characterisation work must be implemented [2].

To this end, multivariate analysis has, among other methods, proved helpful for the characterisation and classification of plant genetic resources evaluated for several phenotypic and agronomic traits [5]. To alleviate the problem and provide farmers with other alternative varieties, reports on the development of protocols for the characterisation and improvement of Okra accessions in Ethiopia. Production of Okra still depends on local varieties maintained by farmers. Okra (Abelmoschus esculentus) is an annual shrub cultivated in tropical and subtropical regions worldwide and is a popular garden and farm crop. It is a widely cultivated food crop and is globally known for its palatability. Okra seeds have been reported to have protein compositions different from those of cereals and pulses, as their protein ingredients are modified to balance the characteristic amino acids, namely lysine and tryptophan. Thus, owing to their high content of essential amino acids, okra seeds are an important constituent of the human diet. Okra pods are also reported to be rich in nutrients and are frequently consumed after boiling, frying, or other cooking methods. Subsequently, the anticancer effects of okra seed extracts have also been documented in vitro through several different cell lines. The flavonoid constituents of seed extracts exhibited enhanced cytotoxic effects on human-derived breast cancer cells (MCF-7) compared with human hepatoma (HepG2) and human cervical cancer (HeLa) cells in a dose-dependent manner. These observations affirmed that the flavonoid isoquercitrin, in a synergistic association with other flavonoids, inhibited vascular endothelial growth factor (VEGF), thereby inducing apoptosis of cancerous cells [34]. The seeds are sown at the beginning of summer by broadcasting, then covered with soil at a spacing of 1 unit. They were about hand-planted by placing two seeds per hill at inter- and intra-row spacing of 70 cm and 30 cm, respectively [35]. Row spacing strongly affects yield, whereas spacing between rows affects yield and average fruit weight per plant. Evaluation of locally available Okra germplasm and selection of the best genotypes are the second approaches being practised by the Okra improvement program. The third approach, crossing and evaluation of progenies for various traits, which is still in its infancy, was less practised in Ethiopia until recently.

VII. NUTRITIONAL, MEDICINAL AND ANTI-NUTRITIONAL RESEARCH

A. Proximate Value

The proximate compositions of thirteen okra pod accessions are summarized in (table 1). The result showed that the moisture content of fresh okra pod accessions varied from 89.07 to 91.46% on a wet basis. Moisture content indicates the susceptibility of samples to microbial activity and is an index of water activity. Ash content, which reflects mineral content, ranged from 7.16% for P-08 to 8.25% for M-10B and showed significant differences among accessions ($P \leq 0.05$). The results were in line with those of other okra pod genotypes (Agbagoma and Balabi), with ash content ranging from 7.70 to 7.80% [32]. The protein content ranges from 18.20% for M-12B to 22.06% for Humera, with significant differences ($P \leq 0.05$) among okra accessions. This indicates that varieties significantly influence protein content. Also, the result is in agreement with the findings reported by [13]. This variability may be associated with the main effect of genetic factors. However, the okra pod accessions in this experiment have shown lower protein content than some results, such as [34], which reported 47.80-48.00% protein. The result also indicates that crude fibre content differs significantly ($P \leq 0.05$) among accessions. The highest crude fibre (5.98%) was obtained from the Humera accession, and the lowest (1.66%) was obtained from accession M-10B. The crude fibre content of all okra pod accessions is somewhat lower than that reported, with crude fat ranging from 0.88 to 1.43%. The highest fat content (1.43%) was recorded for accession M-27C, whereas the lowest (0.88%) was recorded for accession M-9A. These values are in line with the fat content (0.56 to 2.49 %) of okra genotypes reported by [24], but lower than that of Nigerian local varieties (9.03-10.57%). The carbohydrate content ranged from 52.71 to 60.67% and differed significantly among okra pod accessions ($P \leq 0.05$). The highest carbohydrate content (60.67%) is observed in accession M-12B, and the lowest (52.71%) in accession Humera RA. The result falls within the carbohydrate content range of two okra varieties (63.06 to 64.38 %). The okra pod accessions have high protein content ranging from 18.20 to 22.06%. Therefore, it could be a good protein supplement for other cereal-based foods. The result also suggested wide variation in proximate composition among okra accessions. Thus, breeders should also consider the nutritional and anti-nutritional profiles when selecting varieties. However, further research is needed on the processing methods that influence the nutritional quality of okra pods.

Table I: Proximate Composition of Okra Pod Accessions

Accession	Moisture	Ashe	Protein	Crude Fat	Crude Fiber	Carbohydrate
	89.53ghi	7.50bcd	22.06a	1.28b	5.98a	52.71
HUMERA	91.46a	8.25 a	20.51c	1.24c	1.66g	59.80b
M-10B	89.07j	7.25cd	18.20f	1.16f	1.79g	60.67a
M-12B	89.98de	7.60bcd	19.55d	1.23cd	3.16d	58.44def
M-12E	89.80ef	7.50bcd	19.48d	1.19e	3.71c	57.92f
M-13A	89.38i	7.50bcd	19.48d	1.15fg	3.33d	57.92f
M-14A	89.43hi	7.75abc	20.46c	1.22d	1.78g	58.22e
M-17A	90.01d	7.67bc	20.48c	1.12h	2.66e	58.08f
M-24B	91.15b	7.84ab	20.42c	1.43a	1.85g	59.61bc
M-27C	90.51c	7.71bc	19.75d	0.91j	3.22d	58.92cd
M-30A	89.66fg	7.83ab	21.13b	0.88k	4.35b	55.47g
M-9A	89.60fgh	7.16d	20.22c	1.14g	2.27f	58.81de
P-08	90.55c	7.85ab	19.08e	0.99i	2.39ef	60.25ab
P-2P1	90.01	7.65	20.06	1.15	2.93	58.22
Mean	0.14	3.91	1.09	0.80	7.62	0.71
CV	**	*	**	**	**	**
Sig. (P<0.05,0.01)						

Where: CV= coefficient of variation. Numbers in the same column followed by the same letter(s) are not significantly different at α. The nutritional composition of Okra is presented in Table I. A wide variation was observed across most biochemical characters studied. Generally, biochemical analysis revealed that Anchote leaf contains higher food energy and total carbohydrate than Okra, and contains substantial amounts of crude protein, crude fibre, calcium, magnesium, and iron (Table I).

The mineral nutrient content of Okra is essential for maintaining normal cellular homeostasis. So, it is crucial to investigate and select accessions with higher mineral nutrient content, as they have a pronounced effect on the mineral nutrient content of Okra pods. According to [36], edible plant parts have been documented to contain calcium (Ca), phosphorus (P), and iron (Fe) in different amounts of 84, 90, and 1.20 mg, respectively. It also contains β-carotene, riboflavin, and vitamin B complex at the approximate concentrations of 185 g, 0.08mg, and 0.04 mg, respectively. The remaining mineral composition is presented in Table 2.

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Table II: Mineral Intake from 100g of Okra

Mineral Composition	Amount Per Serving
Calcium (mg)	81.
Phosphorus (mg)	63
Iron (%)	0.8
Potassium (%)	303
Magnesium (mg)	57.
Copper (mg)	0.1
Zinc (mg)	0.6
Sodium (mg)	8.0
Manganese (mg)	1
Selenium(mg)	0.7

B. Medicinal Research

Phytochemicals are the non-nutritive bioactive compounds produced by plants through various metabolic pathways. The various phytochemical compounds commonly present in plants include steroids, terpenes, flavonoids, coumarins, alkaloids, xanthones, benzophenones, tannins, phenolic acids, saponins, anthocyanidins, reducing sugars, glycosides, and antioxidant micronutrients [19]. Various phytochemicals present in Okra have numerous medicinal uses, as highlighted in this review. Many studies have shown that, due to the presence of multiple phytochemicals, Plant-based foods, including fruits and vegetables, are excellent sources of bioactive phytochemicals [3].

C. Effects on Cardiovascular Diseases

Foods commonly associated with polyphenolic contents have antioxidant protection from free radicals and phytoalexins to prevent non communicable diseases such as heart disease, inflammation, cancers and diabetes Flavonoids are phenolic compounds based on C15 (C6C3C6) framework bio active component such as derivatives oligomeric catechin and Flavonol derivativesves prevents and used treating of chronic ailments including cardiovascular disease and cancer and addittinally for treating of vascular diasese resulted in reducing ris of disease [8].

D. Cancer

Anti-cancer activity and other health benefits provided by β-carotene include protection against cardiovascular disease and cataract prevention. β-carotene, β-cryptoxantin, and the outcomes associated with asthma and allergy. β-Carotene is ubiquitously present in green leafy vegetables and yellow-orange fruits: a primary energy source and fuel for the brain, kidneys, heart, and muscles.

E. Blood Pressure

Bioactive compounds constituting mineral Tannis, antioxidant efficacy of these formulations in vitro, and okra poly shards. Nutraceuticals have proven health benefits, and consuming them within their recommended dietary intakes may help prevent disease and maintain overall good health. Therefore, since various parts of okra (fruit, seed, pulp, and mucilage) have several therapeutic uses, it can be considered a vital vegetable crop for controlling or reducing Blood pressure [28].

F. Effect on Gastrointestinal Tract Problems

Fibre content in Okra has been directly linked to improving several conditions within the human body, but the most obvious is its effect on digestion. Fibre bulks up stool, which helps move it through the digestive tract, thereby eliminating constipation, bloating, intestinal pain, and even more serious conditions like colorectal cancer. Moreover, fibre helps boost heart health by removing excess cholesterol from the walls of arteries and blood vessels, thereby helping prevent atherosclerosis and associated issues such as heart attacks and strokes [17].

G. Cholesterol Disease

Bioactive compounds constituting mineral palemetic, Oleic acid, linoleic acid, and antioxidant efficacy of these formulations in okra poly shards. Nutraceuticals have proven health benefits, and consumption at recommended levels can help reduce cholesterol levels [12].

H. Anti-Nutritional Research

Anti-nutrients are referred to as nutritional stressors, which may be synthetic or natural compounds that impede nutrient absorption. Antinutritional factors such as phytate, oxalate, and tannin can form complexes with metallic ions, including Cd, Mg, Zn, and Fe, as well as other minerals, thereby decreasing their bioavailability [30]. Anti-nutritional factors (ANFs) are considered nutritionally undesirable since they can limit the digestibility and solubility of specific nutrients, such as protein, calories, minerals, and vitamins. The commonly occurring anti-nutrients include: phytic acid, tannins, cyanides and oxalic acid

I. Phytic Acid

Phytic acid, known as inositol hexaphosphate (IP6), is the principal storage form of phosphorus in many plant tissues, especially in the grass family (wheat, rice, rye, barley, etc.) and beans. Phosphorus in this form is generally not bioavailable to humans because humans lack the digestive enzyme phytase, required to release phosphorus from the phytate molecule.

In plants, phosphorus occurs mainly in two forms: phytate-phosphorus and inorganic phosphorus. Phosphorus in plants is stored in the form of phytic acid (PA), or myo-inositol 1,2,3,4,5,6-hexakisphosphate. Phytic acid accumulation occurs in plant parts. For example, when plants are grown in soil, phytate anions bind protein at pH below the protein's isoelectric point, forming insoluble complexes and inhibiting protein digestion.

J. Tannins

Tannins are secondary compounds of high molecular weight polyphenolics with various chemical structures, widely occurring in the plant kingdom, including many plants used as foods and feeds. Tannins exhibit enormous structural diversity and are classified into two groups based on specific structural characteristics and chemical properties: hydrolysable tannins and condensed tannins.

Tannins that can be broken down, for example, by treatment with hot water or tannases, were classified as hydrolysable tannins. The great variety in the structure of these compounds is due to the many possibilities in forming oxidative linkage.

The production of tannins seems to depend to a considerable the extent to which extrinsic factors, most notably soil conditions and light intensity, and their capacity to precipitate proteins vary across species, as well as within the same species and over time.

K. Cyanide

Cyanoglycosides or cyanogenic glucosides (CG) are produced by about 2650 plant species, and account for approximately 90% of the broader group of plant toxins known as cyanogens. Cyanide or hydrogen cyanide (HCN) is obtained from the hydrolysis of the two CG, linamarin (93% of the total cyanide content) and lotaustralin. These two CGs can be hydrolysed to hydrocyanic acid by the endogenous enzyme linamarase, which produces acetone cyanohydrins when plant tissues are damaged, and the linamarin present in the vacuole is brought into contact with this enzyme during harvesting or processing.

Cyanide has a toxic effect when converted to thiocyanate, a sulfur-containing compound, by the enzyme rhodanase after entering the bloodstream. This compound plays its toxic role by using up body sulfur during detoxification, thus increasing the body's demand for sulfur-containing amino acids, or by interfering with the thyroid's iodine uptake, resulting in goitre. Chronic, low-level cyanide exposure resulting from eating poorly processed high dietary cyanide exposure, like cassava, results in the development of goitre and tropical ataxic neuropathy.

L. Oxalates

Oxalates are dicarboxylic acids found in plant-based foods such as cassava, which can reduce the bioavailability of magnesium and calcium. These anti-nutritional agents bind calcium, leading to the formation of crystals or their excretion through urine. The crystals that form (calcium oxalate) are the major contributors to kidney stones. It is highly advisable to reduce oxalate intake and promote calcium intake among individuals at risk of kidney stones. Less attention had been paid to the importance of oxalate levels in foods until recently, as it was believed that only 10% of the calcium excreted daily was due to dietary calcium. The impact of oxalates on human health depends heavily on calcium availability and the amount of oxalate consumed.
Phytate (mg/100g

Table III: Anti-Nutrient Levels (Mg/100 G) Of 13 Okra Accessions in Wet Weight

Accession	Oxalate mg/100g	Phytate (mg/100g)	Tannin (mg/100)
HUMERA	0.56e	0.30	6.4
M-10B	0.73a	0.33	6.5
M-12B	0.71ab	0.33	6.5
M-12E	0.72ab	0.34	6.5
M-13A	0.68abc	0.31	6.6
M-14A	0.63cd	0.33	6.5
M-17A	0.66bcd	0.31	6.6
M-24B	0.62d	0.32	6.6
M-27C	0.73a	0.32	6.7
M-30	0.71ab	0.33	6.6
M-9	0.73a	0.32	6.6
P-08	0.65cd	0.33	6.5
P-2P1	0.72ab	0.33	6.5

M. Types of Diseases and Pests Affecting Okra

i. Diseases of Okra

Okra is an annual shrubby horticultural crop with resistance to a lot of pests and diseases, but a few diseases may occur, including the commonly known disease of okra, yellow–vein mosaic virus [15]

ii. Yellow Vein Mosaic Virus

A uniformly interrelated network of veins surrounds islands of green tissue inside the disease, and finally, the leaves of the disease turn yellow.

iii. Okra Enation Leaf Curl Disease

Pin-sized enations on leaves are the disease's initial symptoms. Leaves with warts and a rough feel come next. The leaves eventually start to curl adaxially. Together, they are the hallmark symptoms of the disease. Infected plants produce small, distorted fruits.

iv. Cercosporal leaf Spot (Cercospora malayensis and C.abelmoschi):

Brown and irregular Spots are caused by Cercosporal malayensis, whereas Cercospora aelmoschi causes sooty black and irregular spots. Both leaf Spots significantly reduce leaf cover when wet. The fungus lives on crop waste in the soil.

v. Insect Pests

Many insects damage or attack okra. Among those, the most important insect pests are the shoot and fruit borer (Eairs Vittella), cotton leaf hopper (Amrasca biguttula iguttula), White fly (Bemisia tabaci), Leaf roller (Sylepta derogate), Dusky cotton bug (Oxycarenus hyaline pennies) and Blister beetle (Mylabris pustulatus). These are all pests, the most severe and profound insects that regularly occur in potential areas across all Okra-producing areas (Freeick et al., 2019) [11].

VIII. CONCLUSION

Okra's significant contributions to the well-being of smallholders in Ethiopia include nutrition, treatment of various diseases, medicinal value, and foreign exchange at the national level. However, its importance at the community level was less recognised when production was low, fewer extension services were provided to farmers, and the prevalence of pests and diseases was high. Sown okra, especially when integrated with other crops and trees under proper management, increases system productivity, resilience and livelihoods. They also provide other ecosystem services and reduce the ecological footprint per unit of animal production compared to other crops. Moreover, the Integration of stakeholders such as universities, research institutes, the extension sector, the private sector, and the farming community could bring vital change to the sector's transformation. Overall, the review suggests that okra pods with high proximate concentrations and high mineral content among accessions could serve as a baseline for the breeder. Therefore, the breeder must use the suggested document on nutritional and antinutritional factors to improve the selected Variety.

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