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Phytochemistry, Pharmacology and Nutraceutical Potential of Enset (*Ensete ventricosum)*

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***Abstract*-- Enset (*Ensete ventricosum*) belongs to family Musaceae is a plant native to Ethiopia, it is often called false banana for its close resemblance to banana plant. Enset is drought-tolerant, multi-purpose crop which has been part of a sustainable cropping system with high agro-biodiversity in Ethiopia. It could improve food and health security in the country especially where other options is low. Enset plant contains starch and other minor/trace elements which contributes in its nutraceutical applications. Starch is major constituents of the plant and play crucial role in pharmaceutical activities including: Tablet binder and disintegrant, Pharmaceutical gelling agent, Sustained release agent. Nutrional values and major food products of enset, namely Koch, amicho and bulla along with medicinal values encompasses; anti-microbial, anti-nematodal diseases of humans, expel of placenta, healing bone fracture are some nutraceutical applications of enset.**

***Keyword*-- Enset, Enset starch, Pharmaceuticals, Nutraceuticals**

I. INTRODUCTION

Enset (*Ensete ventricosum* (Welw.) Chessman belongs family Musaceae, genus Ensete which comprises about 7 species, among these *E. perrieri* found in Madagascar, Ensete gillettii (De Wild.) Cheesman is native from Sierra Leone, Angola and Malawi, and Ensete homblei (De Wild.) Cheesman is native to southern Democratic Republic of Congo and northern Zambia, *E. superbum* and *E. glaucum* grow wild in Asia, *E. ventricosum* in Ethiopia [19]. *Ensete ventricosum* is a perennial, herbaceous, monocarpic and monocotyledonous plant [22]. Enset is related to and has physical resemblance with the banana plant and as a result it is sometimes known as a false banana.

Ensete ventricosum, previously, grown in Ethiopia especially in the south and south-western par, but the recurrent droughts and environmental factors have led to the expansion of enset cultivation to other parts of the country to secure food and health of the peoples. A wide range of adaptation within the species to altitude, soil and climate has c prevalent cultivation of the crop in western Bale, south-western Oromia including south and east Shewa, Jima, Illubabor and Welega [18].

Wild enset grows at altitudes of 1200–1600 m above sea level while domesticated enset is cultivated at altitudes of 1100–3100 m above sea level [4]. The optimal conditions for enset cultivation occur at 2000–2750 m with 1100–1500 mm rainfall, a temperature range of 10–21 ºC and a relative humidity of 63–80% [8]. Enset often grows best in acidic, heavy clay soils that retain high levels of organic matter [20]. Enset is a crop that tolerates prolonged drought periods, flooding and many diseases. Due to its drought tolerance, it is regarded as a priority crop in Ethiopia, where it makes a major contribution to the food security of the country.

Enset has remarkable significance in day-today-life of the peasant households cultivating the crop as staple food. The peasants indicate that enset is their food, their cloth, their house, their bed, their cattle-feed and their plate. It ranked as cultivated staple food and medicinal crop in the highlands of central, south and southwestern Ethiopia [10]. Enset is considered an economic crop in Ethiopia due to its high yielding potential wide adaptability, resistance to drought, and multifunctional usage. It is a rich source of starch and is utilized as food locally known in Ethopia as *kocho, bulla, amicho* and *Workay* (rarely) [13].

The yield of *Ensete ventricosum* products is determined by the type of landrace grown, climatic factors, soil fertility, the time to maturity, the methods of processing and the length of the fermentation period.

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One plant of 5 years old could produce up to 21 kg of local food (Kocho, Bulla and Amcho) and 3.6 t/ha dry matter residue. The fresh yield of kocho is 16–42 kg/plant or 12–25 t/ha/year. The fiber yield of enset has been estimated at 500 g per plant [23] .

Phytochemical analysis of the seeds revealed presence of Alkoids, steroids, phenolics, glycoside and sugars various pigments liker chromatin derivatives (contain no streroidal physterol) isolated from seeds of enset and evaluated on the basis of physical and spectral data can be further validated by HPLC and HPTLC as a marker compound for elaborate antifertility studies, These compounds find use in medicine, cosmetics and as food additive to reduce cholesterol. The ayurvedic system of medicine psedustem and seeds of enset are used for the treatment of various human aliments like debility diabetes, kidney stone, leucorrehoea, measles, stomachache and easy delivery [19].

Additionally, Enset starch has tremendous constitute which contribute in its pharmaceutical applications including binder, disintegrant, super disintegrant, and gelling agent, repair broken bones, facilitate abortions or discharge placentas after birth in both cattle and humans, and possess antimicrobial properties [9]. Thus, the focal point of the present work is to give a sneak review on Phytochemistry and Nutraceutical Potential of Enset (*Ensete ventricosum*).

II. Overview Of Enset

Enset is perennial giant herb composed of three main parts, an underground corm, an aerial pseudostem made of overlapping leaf sheaths, and several broad leaves [5]. The pseudostem formed of overlapping leaf sheaths, root system usually adventitious. Leaves arranged spirally, arising from the apex of the corm, with elongated leaf sheaths; lamina oblong to oblanceolate oblong, up to 5 m × 1.5 m, entire, with strongly channelled midrib and many parallel lateral veins, bright to dark green, midrib, petiole and margin sometimes pale to dark red or dark purple, rarely the lower side reddish. Inflorescence a terminal thyrse growing up through the centre of the pseudostem and thus appearing to arise from its apex, bearing cincinnate flower clusters in axils of spathaceous bracts on an indeterminate main axis, exserted part of inflorescence commonly 1–2 m long, drooping [20]. Flowers unisexual, zygomorphic, functionally female ones on the proximal part of the inflorescence, male ones on the distal part; male flowers with one 3-lobed outer tepal up to 5.5 cm long, white with orange-yellow tips.

Fruit an oblong-obovoid berry, 8–15 cm × 3–4.5 cm, orange when mature, rather dry, fibrous, 1–10-seeded. Seeds irregularly subglobose, about 1.5–2.5 cm in diameter, black [5].

Ensete ventricosum occurs naturally in montane forest and riverine forest, often in clearings, gullies and near streams. Naturally, it can adapt a wide range of geographical location with altitude ranged from 100 to 3100. However, it grows best at elevations between 1800 m and 2450 m, an average annual rainfall of 1100–1500 mm., monthly annual temperature of 16–20°Care optimal, but growth can tolerant 5–25°C. Enset grows well in most fertile and well- drained soils, ideally moderately acidic to alkaline (pH 5.6 - 7.3) with 2–3% organic matter [15]

III. Phytochemistry And Pharmacology Of Enset

3.1. Phytochemistry of Enset

Enset has tremendous biological active components which contribute in its pharmaceutical and nutraceutical applications. Enset starch on dry weight basis consists of 99.24% starch. The AM content is 29% and the starch granules are angular–elliptical in shape with a mean size of 46 mm [7]. Enset starch exhibits typical XRD pattern of B-type with a distinctive maximum peak at around 17'' 2*u*. Its swelling power and solubility values were lower than potato starch but much higher than maize starch. Enset starch has a gelatinization temperature of 61.8–71.78 C and the peak viscosity of 6% starch paste has been found to be lower (884 BU) than potato starch (1668 BU) but higher (302 BU) than maize starch [7]]

Starch

Starch is major constituent of enset which contributes in its pharmaceutical and nutraceutical values. Starch is semi crystalline in nature with varying levels of crystallinity. The packaging of amylose and amylopectin within the granules has been reported to vary among the starches from different species. The activity of the enzymes involved in starch biosynthesis may be responsible for the variation in amylose content among the various starches [10]. Starch granule differences amongst various plant species are accounted for, not only by the ratio of constituent molecules, but also by their location and interaction and it is probably the most commonly used hydrocolloid. Starch granule differences amongst various plant species are accounted for, not only by the ratio of constituent molecules, but also by their location and interaction and it is probably the most commonly used hydrocolloid.

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The crystalline composition consists of around 15-45% of the starch granules. The crystallinity is exclusively associated with the amylopectin component, while the amorphous regions mainly represent amylose [26].

Amylose

Amylose is defined as a linear molecule of D-glucopyranosyl units joined by ∞ (1 4) linkage, but it is today well established that some molecules are slightly branched by ∞ (1 6) linkages. The amylose is essentially linear but not purely and its solution properties are generally regarded as typical for those of a linear polymer [17]. The inside of the helix is lipophilic where there are only hydrogen atoms. On the outside, there are hydrophilic hydroxyl groups. The exact position of amylose in the granules is uncertain, but it is generally believed that it acts as an amorphous space filler in the granules, whereas the amylopectin is highly branched with shorter chains arranged as double helices in clusters of a partially crystalline character [24]. Amylose is located in the granule as bundles between amylopectin clusters and or randomly dispersed. In starch granules, the amylose chain displays a natural twist in a helical conformation with six anhydroglucose units per turn [25]. The ability of amylose to form complexes with butanol provides a method for separating amylose from amylopectin by selective precipitation.

Amylopectin

Amylopectin is the highly branched component of starch and it is formed through chains of ∞-D glucopyranosyl residues linked together mainly by ∞ (1 4) linkages but with 5–6% of ∞ (1 6) bonds at the branch points (Fig 1).

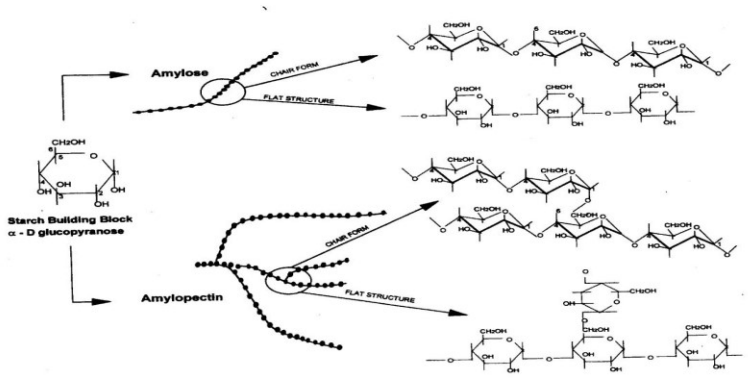

Fig 1. Structure of amylose and amylopectin molecules

Other components in Enset starch

The extracted starch is invariably accompanied by various other components viz., fiber, lipids, proteins and minerals, depending on a number of factors such as method of extraction, age of the crop, and environmental conditions. Some of these impart desirable qualities to the starch, while others affect the quality [13]. Proximate composition analysis of the enset starch showed 14.0% (w/w) moisture, 0.35% (w/w) protein, 0.25 % (w/w) fats, and 0.16% (w/w) ash [8]. A study also revealed that fat and protein content of enset starch was significantly higher than potato starch but lower than maize starch. Enset starch contained higher content of ash than maize starch, but lower than potato starch.

3.2. Pharmaceutical Application of Enset

Enset starch has remarkable pharmaceutical application including:

3.2.1. Tablet binder and disintegrant

The binding and disintegrant properties of enset starch have been evaluated in chloroquine phosphate, dipyrone, and paracetamol tablet formulations and compared with tablets prepared with potato starch [6]The results revealed that enset starch had a better binding ability giving tablets of lower porosity and friability, but higher crushing strength than potato starch [6]. Similarly, the binding and disintegrant properties of pregelatinized enset starch were investigated [25]. The result of the study revealed that pregelatinized enset starch demonstrated comparable binding and disintegrant property with that of Starch (commercially available partially pregelatinized corn starch).

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3.2.2. Super-disintegrants

Although the native starch has been widely used as a tablet disintegrant, the softening effects it has on a tablet at an effective concentration along with the increasing demand for faster disintegration, dissolution and improved bioavailability of drugs administered by conventional oral tablets has resulted to some extent in its replacement by more active disintegrants, such as super-disintegrants. These super-disintegrants include sodium starch glycolates, cross-linked polyvinyl pyrolidone and cross-linked carboxymethyl cellulose. Sodium starch glycolate is the sodium salt of a relatively low substituted carboxymethyl ether of a native starch prepared by both crosslinking and substitutions. The drug indicates its ability to sustain drug release and their potential to be used as drug-release-sustaining pharmaceutical excipient. In another study, enset starch acetate with degrees of substitution of 2.142 and 0.672 were evaluated for direct compressibility and drug release sustaining properties. The result showed that high degree of acetylation renders enset starch to sustain the drug release for more than 12h and highly compressible [14].

3.2.3. Pharmaceutical gelling agent

The application of native starch as the pharmaceutical gelling agent has been reported, but discouraging mainly because of the need for a high concentration and heating to obtain a viscous gel, the opacity of the formed gel, and its poor stability compared to other gelling agents [11]. Several reports indicate that carboxy methylation improves aqueous dispensability and cold storage stability of starch pastes. These improved properties suggest the potential application of carboxy methylated enset starch (CMS) as a pharmaceutical gelling agent. A study was conducted by Gabriel and his co- workers to investigate carboxymethylated enset starch as disintegration efficiency of a sodium starch glycolate pharmaceutical gelling agents prepared from enset starch was evaluated in α-lactose monohydrate and dicalcium phospahe dehydrate tablets by comparing similar tablets containing sodium starch glycolate from potato starch [8]. The finding showed that the disintegration efficiency of sodium starch glycolate prepared from enset starch is proficient.[14]

3.2.4. Sustained release agent

Enset starch, cross-linked using sodium hexametaphosphate (SHMP) in solid phase systems under different microwave powers and reaction times, has been used for the preparation of starch microspheres as sustained release agent. It was found that the cross- linked enset starch sustained the release of the drug for nearly a day [2]. Comparative study of the physicochemical, drug loading and releasing properties of cross-linked cassava, enset and potato starches, using sodium hexametaphosphate (SHMP) as cross-linking agent also showed that cross-linked enset starch loaded higher amount of drug in 0.1 N HCl, 0.9% NaCl and pH 7.4 phosphate buffered saline media as compared to cross-linked cassava and potato starches. After 12 h, cross-linked enset starch matrix released about 90% of different topical gel formulations of ibuprofen were prepared. All formulations were evaluated with respect to cosmetic qualities, pH, drug content, viscosity, spreadability, extrudability, in vitro drug release, anti-inflammatory activity and stability. The ibuprofen gels exhibited significantly higher anti-inflammatory activity in mice compared to the standard 1% indomethacin gel and they were found to be non-irritant and physicochemically stable. Indicating the potential use of carboxy methylated enset starch as effective gelling agents in topical preparations.

IV. Nutraceutical Application

4.1. As Medicine

The enset plant and its parts contribute to indigenous ethno-medicinal values of the society. Enset is used as a staple and co-staple food for millions of Ethiopians. Products from enset are used in different forms in traditional and modern medicine including expel of placenta, healing of bone fracture, anti-microbial activity against viral, bacterial, fungal and nematodal diseases of humans.

Phytochemical analysis of enset seeds revealed presence of Alkoids, steroids, phenolics, glycoside and sugars various pigments liker chromatin derivatives (contain no streroidal physterol) isolated from seeds of enset and evaluated on the basis of physical and spectral data can be further validated by HPLC and HPTLC as a marker compound for elaborate antifertility studies [17].

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4.2. As Food

Enset produces a starchy, carbohydrate-rich food for human consumption. The nutritional content of different fractions of enset water content, 85 to 90%, enset corm contained 17 of 20 amino acids and had similar or higher concentration than potato. Nutritionally, the leaves of enset had 13% protein, among the highest available in Ethiopia, 20% crude fiber and 10% sugar; a good fodder and suitable for ensilage. The pseudo stem, the main food source, was rich in soluble carbohydrates (80%) and starch (65%), but had low protein content (4%) [12], [20]

The major foods obtained from enset are kocho, bulla, Workay and amicho. By mixing pseudostem, corm and the stalk of the inflorescence allowed for fermentation in the pit [3]

Kocho (Local. Uncha) is the decorticated (scraped-off) mass of the leaf sheaths, which collectively make up the pseudostem of the enset plant. The fermentation product was commonly called "Kocho". It is the bulk of the fermented starch obtained from the mixture of the decorticated (scraped) leaf sheaths and grated corm (underground stem base). Kocho can be stored for long periods of time without spoiling. The quality of kocho depends on the age of the harvested enset plant, the type of clone (variety), and the harvesting season Moreover, within one plant, the quality is influenced by the part of leaf sheath and corm processed. The preferred type is white in color and is obtained from the innermost leaf sheaths and inner part of the corm, while the lowest grade is blackish and is obtained from the outer leaf sheath and corm.

From Koch different dishes are prepared in the form of bread and porridge. Further Pseudostem can be consumed directly by chopping and cooking it with mixing cabbages, and potato in same parts of the region. Corn can be cooked fresh and consumed in ways similar to Irish potato, sweat Potato or cassava [16]. The optimal harvesting time of enset for the preparation of kocho is soon after the appearance of the inflorescence.

Bulla is prepared by kneading fresh unfermented kocho and squeezing out the liquid, which is rich in starch. The liquid is collected and the starch is left to settle. The liquid is then discarded and the bulla is left to dry and fermented in a way similar to kocho.

Workay (locally Godeta) is part of the corm, which is pounded up by a harvesting/processing pestle with teeth.

Amicho (local. Doysetida utta) is the boiled up corm, which has not been pounded but has been cut up into large chunks. Amicho is usually made from immature or matured female enset plants/ obtained from the underground corm that is eaten boiled.

Additionally, enset flour is also mixed with flour from cereal crops such as tef (*Eragrostis tef*) to make the traditional Ethiopian bread,'injera' and other staple food[1].

The main feature of enset foods is their high energy value (1410–1950 kJ per 100 g dry matter of kocho, 1580–1850 kJ per 100 g dry matter of bulla), derived almost entirely from carbohydrate. Fresh kocho contains 47–62 g moisture per 100 g. Per 100 g dry matter the approximate composition of kocho is: protein 1.1–2.8 g, fat 0.2–0.5 g, carbohydrates 95–98 g, fibre 2.3–6.2 g, ash 1.7 g, Ca 60 mg, P 68 mg, Fe 7 mg, thiamine 0.06 mg, riboflavin 0.08 mg, niacin 0.6 mg. The moisture content of bulla ranges from 44–55 g per 100 g fresh material. Per 100 g dry matter the approximate composition of bulla is: protein 0.4–0.8 g, fat 0.2–0.4 g, carbohydrates 93–98 g, fiber 0.6– 0.8 g, ash 0.2 g, Ca 91 mg, P 44 mg, Fe 5.8 mg, thiamine 0.02 mg, niacin 0.2 mg [16], [21].

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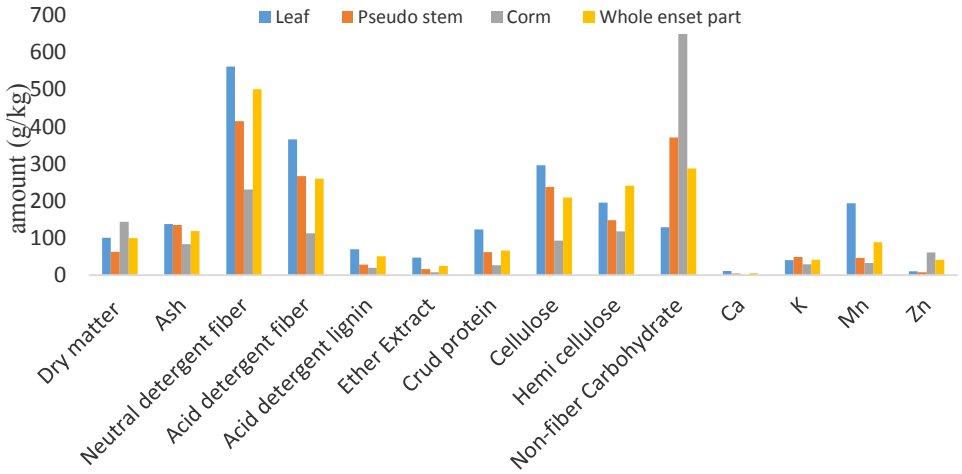

fig 2. Nutritional constitiuents of Enset parts

V. Conclusion

Enset is life sever crop with numerous remarkable role in food and health security due to its prominent stored potentials for long period of time; harvested at any time and stage over a several period during the year and survival of environmental stress that reduce the productivity of other crop. Food product from enset and its parts are rich carbohydrate, energy and mainly used as a staple and co-staple foods. Moreover, Enset has a starch as major constituent which contribute in its pharmacology and nutraceutical applications. Enset starch demonstrated numerous pharmaceutical applications, including binder, disintegrant, super disintegrant, and gelling agent. The cross-linked and acetylated form of enset starch showed their potential use as a novel drug delivery system. Additionally, enset starch have nutraceutical values encompasses food. Hence it can be concluded that enset is multipurpose crop with proficient potential in food and health security. The major constituent of enset is its starch which contributes in its pharmaceutical and nutraceutical values and it can be used as alternative starches source in pharmaceutical industries.

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