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AN OVERVIEW ON ENSETE (*Ensete ventricosum*)
RESEARCH AND FUTURE TECHNOLOGICAL
NEEDS FOR ENHANCING ITS PRODUCTION
AND UTILIZATION¹

Taye Bezuneh²

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1. Paper prepared for the First International Workshop on Ensete Crop Improvement, Processing and Utilization, Addis Ababa, Ethiopia, 12-20 December, 1993.
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ABSTRACT

Ensete was established as a separate genus within the family *Musaceae*, about five decades ago (Cheesman, 1947). In this paper, ensât refers to the vernacular name of the genus. Among the few known species distributed within Africa and Asia, *Ensete ventricosum* is the dominant type that has been cultivated for food and fiber in Ethiopia, although other ornamental types are also common (Taye, B. et al. 1967, and Simmonds, N.W. 1958).

Initially, the ecological distribution and the diversity of the genus is reviewed, followed by an examination of the state of knowledge on the various aspects of ensat research and improvement during the past three decades. These include: (i) agro-botanical investigations focussed on the collection, classification and selection of clones for food and fibre production; and (ii) analysis of ensat-based farming systems to revitalize agronomic research and improve traditional technologies in processing and utilization of ensat.

Accelerated food production (at least by 5% increase per year), in the 1990s and beyond is crucial for Ethiopia's survival, while intensification of agricultural production and improving productivity is a viable option. Finally, the paper proposes future research and technological needs for the development of ensat-based sustainable food production systems, which maximize the utilization of indigenous resources available on-farm, based on ecological principles, economic and environmental concerns.

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Introduction.

The ensat plant is one of the major sources of food (carbohydrates) and fiber for several million people in southern, central and south-western Ethiopia. Its cultivation is estimated to cover close to 70,000 km² in these regions. The parts of ensat used for food include: the pseudostem pulp, the young shoot and the under ground rhizome. Following the fermentation of the parenchymatous tissue of the pseudostem and the underground portion of the plant (rhizome), two types of ensat products (flour form) are obtained. In some instances, the shoot and other parts of the plant are cooked and used as vegetables and tubers crops.

Regions where ensat is cultivated as a major staple food, are among the most densely populated in the whole of Ethiopia. For example the population density in the Gurage, Hadaya/Kembeta region is about 175 and 220 inhabitants per square kilometer respectively.

The ensat plant is also, an important source of fiber, which is used industrially in the manufacture of ropes, sacks, mats, and as a cheap substitute for wool in the weaving of products such as shopping bags, hand bags, suitcases, etc. Annual production of ensat fiber is estimated to be about 12,000 tons, of which 10% is for industrial use.

The ensat-based farming system comprises, the concurrent cultivation or in a rotation of various cereals, tubers, stimulant and oil crops, spices and condiments, horticultural crops, etc.. The intensity of cultivation of any crop in association with ensat, is delineated by its ecological adaptation in three zones of ensat-based farming systems. These are in the upper-high altitude elevation (2500-3000 m), the high altitude (200-2400 m) and the intermediate altitude ecological zones (1500-2000 m).

The sustainability and productivity of ensat agriculture is based on the continuous application of manure to sustain the fertility of the soil. Depending on the size of farm, limited number of livestock are kept to ensure the continuous supply of manure and also to improve the quality of the basic diet, since the preparation of various types of ensat foods are based on milk-by-products.

This paper provides an overview on ensate research and improvement. These include, the collection, characterization and agronomic evaluation of ensat clones; review of the ecological distribution of the genus Ensete in Africa, and its clonal diversity in Ethiopia.

The ensat plant grows tall and robust, ranging from 4 to 11 m in height. Its pseudostem dilates at the base to a circumference of 1.5 to 3.0 m, and the more it is dilated at the base the greater is its yield. The pseudostem length ranges from 2 to 5 m depending on the clone and ecological condition of its cultivation. Its pseudostem and leaf mid-rib colour vary considerably; some are purple to dark red but most are light green with variegated brown patches. Leaves are borne on the pseudostem almost from the same point and on short petioles, and are about 5 m long and 0.75 to 1.5 m wide. The underground portion of the plant consists of a corm which is 0.70 to 1.8 m long with a circumference of 1.5 to 2.5 m at maturity. Unlike cultivated bananas, the fruit of ensat is not edible; the pseudostem and the underground corm are the edible portions of the plant.

Based on cytological, taxonomic and morphological characteristics Cheesman (1947), Simmonds (1953) and Moore (1957) have established the basic differences between Musa and Ensete genera (Table 2).

Collection and evaluation of Ensat Clones.

In the 1970s', several ensat types collected from major ensat growing regions were established both at Debre-zeit and Holetta stations. The vegetative, morphological and agronomic characteristics of nearly 75 collections were recorded. Based on the overall growth of the upper and lower portions of the rhizome, the pseudostem and the number of leaf-sheaths per plant, 9 and 20 promising clones were identified for food and fiber production, respectively (Taye Bezuneh, 1972). Assessment of ensat food production at on-farm level was undertaken in Endiber, Kembata and Sidamo areas, and mean yields of 26 to 42 kg/plant reported (Teketel Makeso, 1973).

Taye Bezuneh (1984) determined the food yield potential of three major ensat clones. The clones were Adow, a major ensat type in the eastern highlands of Sidamo Province; Tuzuma, largely cultivated in the Hadya-Kembata region; and Ferezae, one of the major ensat types in the Wolliso and Wolketie Gurage regions. The ecological adaptation of these clones is in the cooler highlands (1500 to 2800 m elevation), with slightly higher annual rainfall (850 to 2000 mm) and lower temperatures (18 to 23°C) where Adow and Ferezae clones are cultivated, respectively. Furthermore, the farming systems of each of the clones evaluated differ considerably as summarized in Table 3.

After 40 months of growth, the fresh weight and fermented product yield showed variability in yield among the three clones. The "Adow" clone that constitutes most of the plantings in southern Ethiopia gave the highest yield (Fig. 2). The yield of the fermented product as dried "Kocho" flour was

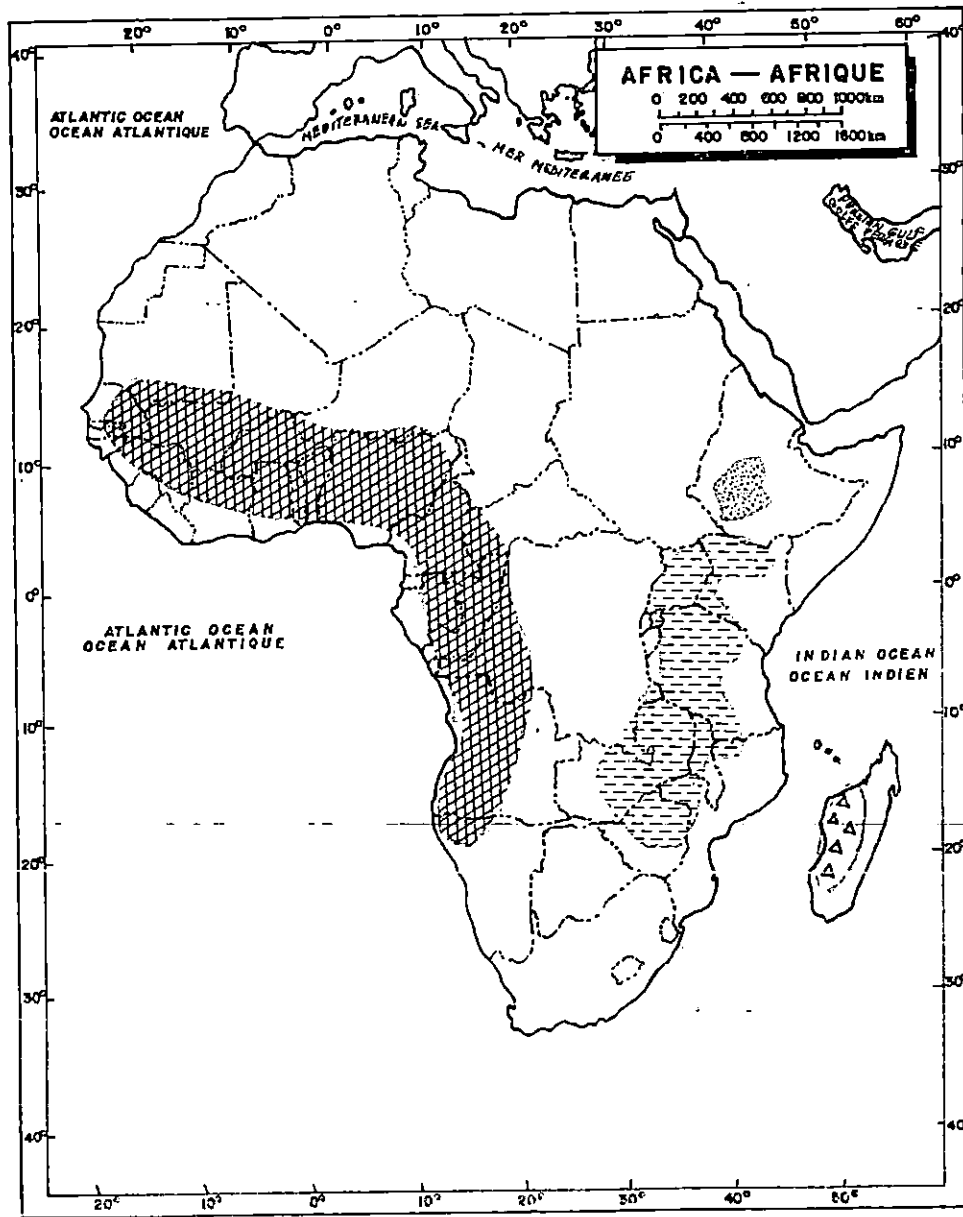


Fig. 11 Distribution of Ensete species in Africa

- ▲▲ Distribution of Ensete pirrieri
- ▣ Distribution of E. gillettii
- ▨ Distribution of E. ventricosum
- ▤ Cultivation of E. ventricosum in Ethiopia

18.5, 22.2 and 29.8 kg per plant/per year for "Ferezae", "Tuzuma" and "Adow", respectively. Yield estimation was based on a five-year growth cycle. In this particular trial, it was evident that the retrieval of ensat food as fresh and fermented product had been low. Food recovery as fermented product varied less within than between clones. This implies the need to improve basic traditional implements being used for the food and fiber extraction.

Ensat food is known to contain 42 to 54% carbohydrate. Based on the yield assessment of ensat at on-farm level and results of experiments discussed above, the carbohydrate production could vary from 17 to 30 tons/ha.

Furthermore, the evaluation of three ensat types namely, Sepre, Siskela and Gimo/Gurage in Wolaita region showed a mean yield of 33 kg/plant, while yields varied from 13 to 59 kg/plant. No significant difference in yield and maturity, however was observed among clones. On the basis of 1600 plants/ha, mean yield of 52.8 tons/ha was estimated (Wolaita Agric. Dev. Unit. Agron. Rep. 1979). Commercial fiber is extracted mainly from the pseudostem. The length of the pseudostem and the number of leaf-sheaths per plant determine the yield of fiber of any particular plant. A number of promising clones has been identified (Taye Bezuneh, 1967 and 1972). In comparison with other fiber crops such as Musa textilis, linum usittatissum, Gossypium spp fiber cells of Ensete are much smaller in length than its closely related genus such as Musa textilis (Robinson et al, 1953, Vetillart, 1896 and Taye B., 1966). Fiber from 20 clones was extracted and evaluated for tensile strength and for related qualities. The result showed that ensat was next to abaca (Musa textilis) intering of the quality of the fiber but, better than sisal and sañsevieria. Currently, the fiber yield per ensat plant varies from 350 to 500 g. Increased production of the fiber could lead to realization of cottage industry, provided that the present crude method of processing and fiber extraction could be improved.

The quality and yield of fiber is expected to vary not only among the various ensat clones, but also due to existing crude methods of fiber extraction. Data on the fiber yield of ensat crop is virtually lacking. Based on the limited data available, the estimated fiber yield could vary from 600-800 kg/ha. (Taye Bezuneh, 1984 unpublished data and W. Godfrey-Sam-Agrey and Bereke-Tsehai Tuku, 1987).

The causal agent of bacterial wilt disease has been identified to be xanthomonas musacearum sp.n. (Yirgou, D. and J.F. Bradbury, 1968). The spread and severity of the wilt disease in various "weredas" of ensat growing regions was surveyed by Dereje Ashagari (1980). He also established both the

duration of infection, host range and mode of transmission of the X. musacearum on the various ensat clones. While the Musa spp were identified as alternate hosts of bacterial wilt by Yirgou and Bradbury (1968), the addition of Canna orchoides to the list was the first report of the pathogen to attack plant species outside the Musaceae family.

Several types of ensat, including few collections from the forest region were screened for resistance to bacterial wilt. Some clones were identified to possess better tolerance to the disease. Based on this study, practical measures for the control of the disease, (pending the availability of resistant cultivars) were proposed (Dereje Ashagari, 1980/81).

There is some evidence of clonal diversity among the cultivated, ornamental and within those ensat types used for medicinal purposes. However, more systematic taxonomic, agronomic and cytological investigations would be necessary to reveal the genetic diversity of the genus Ensete in general, and the several clones cultivated in Ethiopia in particular. Farmers in Ethiopia propagate ensat vegetatively. Occasionally, botanical seeds of ensat germinate gregariously in situ and produce several seedlings in clumps, particularly in open forest, by plants left to fruit and on abandoned sites reverting into forest. Clonal diversity may have been broadened due to random introduction of new plants started from botanical seeds—during the past several decades.

Similar to banana, ensat produces fruits even though not edible. For example, Ensete ventricosum, widely cultivated species in Ethiopia, produces 10-18 fruits in each of 15-20 hands of each bunch. Seeds in each fruit are variable, usually 5-15 in number. In order to identify cultivars of ensat that are resistance to bacterial wilt and other diseases, to select early maturing and high yielding (food and fiber) types, there is need to exploit existing clonal variations. Concurrently the genetic base could be broadened using botanical seeds to generate new types of ensat plants. From fully matured and unstressed ensat plant, 1000 to 3000 plants may be obtained. On the other hand, the germination of ensat seeds is erratic, generally low and may take several weeks. Mechanical scarification or cracking of the seed is known to improve the imbibition of water by ensat seeds. Soaking ensat seeds for 24 hours soon after mechanical scarification is known to improve the germination of the seed by 60-80%. At the most, 300 to 500 botanical seedlings may be obtained from each ensat plant.

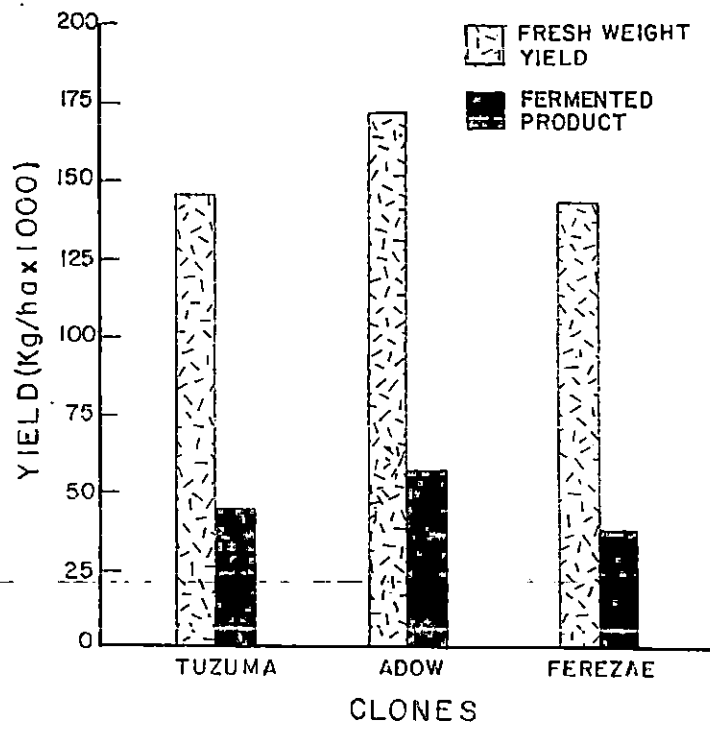


Fig. —² Fresh weight and fermented product yield of three Ensete clones

II. Fermentation and Utilization.

'Kocho' and 'Boula' are the two basic flour products of ensat. The former product has relatively more calcium compared to the latter. The iron content is slightly higher in 'Boula' than in 'Kocho' product according to Berry, F.B. (1959) and analysis by the Ethiopian Nutrition Institute (1972). The carbohydrate content is also higher in 'Boula' than in 'Kocho'.

Besrat *et al.*, (1979) in their investigation of the effect of length of fermentation on carbohydrate, protein and calcium content observed slight decrease in the carbohydrate content (from 50 to 38%) during early phase of fermentation. The cause of the carbohydrate decrease during the early period of fermentation was not thoroughly investigated. The researchers, however suggested that the decrease in carbohydrate content, could be due to the excessive leaching following the peak of microbiological activities. Interestingly, the calcium content of 'Kocho' during fermentation also decreased from 270 to 190 mg/100 gm dry weight in the first five weeks and levelled off at 180 mg/100 gm after 8 weeks of fermentation. The fluctuation of Ca content and other nutrients in 'Kocho' product during fermentation deserves future research attention. It has also been established that the above mentioned ensat food products are low in protein.

Based on the analysis of the 'Kocho' product from 29 ensat clones, Besrat *et al.*, (1979) concluded that, there has been slight decrease in protein content from 3.65 to 3.35% before and after fermentation, respectively. This reduction in protein content, has been attributed to the leaching of the more soluble protein and amino acids. The same authors, also observed improvement of the quality of the 'Kocho' protein, as determined from the amino acid profiles, due to the length of fermentation.

From the above investigation, it was also reported that ensat protein is generally higher in lysine than most cereals, while methionine and isoleucine are the first and second limiting amino acids in ensat food products.

The fermentation process of ensat can be improved not only by the type of implements employed and improving on the 'traditional fermentation system', but also by isolating and culturing micro-organisms involved (for example, yeast in bread) that enhance the process of fermentation. Gashe, (1986) identified diverse group of micro-organisms. He noted that fresh 'Kocho' contains high moisture (84%), a near neutral PH (6.5) and soluble reducing sugars of about 1.5% prior to fermentation. After 80 days of fermentation, the moisture content, PH, and sugars were reduced to 60, 4.2 and 0.3% respectively. This study concluded that, the micro-organisms actively

observed in the 'Kocho' fermentation are similar to those involved in the fermentation of other vegetables (i.e, Leuconostoc spp. and Lactobacillus spp.). Trends of yield of fermented 'Kocho' of some ensat clones is summarized in Table 4. Yield varied from 37 to nearly 67 tons/ha. This variability of yield is perhaps due to methods of yield assessment rather than differences among clones. Further research is suggested to standardize the agronomic parameters for determination of ensat yields.

III. Ensat-Based Farming Systems.

The early evolution of ensat agriculture is the least understood. The cultivation of ensat as staple food crop is found in the cooler high land zones (1600 to 3000 m; 16–20°C). According to Vavilove (1951), Ethiopia is also, the primary centre of origin for the Ensete ventricosum, although its wild relatives occur at lower altitudes in tropical Africa, including Kenya, and Uganda south to Mozambique, etc. (Simmonds, 1958). On other hand, Kul (1958), suggested that the center of diversification of ensat is at the higher elevations in Western Ethiopia (Keffa) where the wild form of ensat occurs.

The ensat farming complex maximize the utilization of internal resources available on-farm. Manure and crop rotation are extensively practiced to maintain soil fertility. Ensat farming is also accompanied with animal husbandary, which provides continuous supply of manure. The preparation of ensat food is also based on milk by-products and meat. These are the major economic reasons for intergrating livestock into ensat farming system.

During the last several decades, ensat cultivation has evolved as one of the most stable and sustainable agricultural development systems, because, the system has been efficient in building and sustaining the fertility of the soil. The concurrent cultivation of crops on the same land with ensat, enabled the system to intensify food production and support more people. For example, the ensat regions are among the most densely populated with 175 to 200 inhabitants per square kilometer in the Gurage and Sidamo areas respectively.

As shown in Fig. 3, ensat is cultivated as a major food crop in the Gurage, Sidamo, Hadya/Kambatta region. The social and economic life and culture of the Gurage people revolves around the ensat cultivation, which satisfy many of their essential needs (Shacks, 1996).

Manuring and crop rotation are extensively practiced. This has enabled farmers to intensify crop production in a sustainable manner (Shack, 1966). In the Gurage region, several crops and some livestock husbandary comprise of the ensat farming systems. Among the cereals, barley, tef and wheat are

cultivated at the relatively high altitude; and maize and sorghum at intermediate highlands. Pulse crops such as horse beans, chickpea, lentil, pea and bean are also cultivated at various ecological zones (Table 5). Furthermore, at between 1600–2000 m elevation, coffee, tobacco, cotton, khat, and sugarcane are the main cash crops grown with ensat. Near the homestead, several types of vegetables (i.e., cabbage, onions, garlic, tomato, potato, taro, etc.) fruits (i.e., papaya, orange, banana, lemon, lime, etc) spices and condiments (i.e. capsicum, pepper, coriander, sweet basil, thyme, etc) are planted with ensat.

Elaborated stages of ensat cultivation practiced in the Gurage region, are not common in the Sidamo/Hadya/Kambatta area. At intermediate altitude (1600–2000 m), coffee, khat, tobacco, cotton are the main cash crops while yam, taro, sweet potato, potato are the most important tuber crops with maize, and sorghum as the most important cereals (Table 5). At the upper-altitude zone (2400–2800 m), barley, wheat, and pulse crops are the most important. At this zone, manuring is not practiced, but soil fertility is maintained through cereal/pulse rotation. Erythrina and other legume which fix nitrogen are planted to help improve the fertility of the soil.

As indicated in Fig. 2, ensat is also cultivated as a co-staple food crop in several regions such as in Wolaita, the Amaro, the Kefa, and the Gamu Gofa regions. Unlike in the Gurage region, most of the ensat types are harvested within four years. Manuring of the crop is not restricted to ensat, although the practice diminishes with distance from homestead (Westphal, 1975). Tuber and root crops are the major staple food. These include: taro, sweet potato, Coleus edulis, which are grown in association with ensat. Ensats are also cultivated as one of the root, tuber and corm crop in Western Ethiopia (Wellega, Kefa and Illubabor). Farmers cultivate various crops, such as tef, maize, sorghum, lentil, chickpea. Among the main garden crops is ensat, Coleus edulis, sweet potato, pea, beans and yam. The main cash crops are coffee, 'khât', tobacco, and cotton.

In the 'Janjero' region (between the little Gibbe and Omo river) in western Ethiopia, the cultivation of ensat is as highly developed as in the Gurage region. Close to 50 types of ensat are recognized. Terracing, rotation and manuring are practiced. Livestock is kept on fallow or uncultivated pasture land.

Based on the above brief review of the traditional ensat based farming systems, the following conclusions may be made:

(a) The type and the intensity of ensat-based cropping system is broadly influenced with changes in altitude. For example, at intermediate altitude, the crops grown with ensat include: the cash and stimulant crops; root and tuber crops, the solanaceous crops, citrus, and several spices and condiments. On the other hand, in the upper-high altitude zone, few crops are grown with ensat. These include: barley, horsebean cabbage, etc.

(b) Large amount of manure and crop rotation are practiced in the ensat-based cropping systems. Depending on the size of the ensat farm, raising of livestock on fallow land, natural pasture and on-crop residue has been a common practice.

(c) With the decrease in altitude from 3000 to 16000m elevation, the importance of ensat as a staple food crop also declines, even though its productivity per unit of land increased.

(d) In general, at intermediate ecological zone, ensat plants mature 2 to 3 years earlier than on the upper-high altitude elevation.

(e) The following types of ensat-based farming systems have been identified:

(i) Cereal economy.

(ii) Cash crop economy. These include coffee, cotton, sugar cane, fruit crops.

(iii) Root and tuber cultivation as main staple food, but ensat cultivation as co-staple crop.

Depending on the ecological zone in which ensat is cultivated, there could be 6-12 harvests for cereals; 4 to 8, for cotton; 1 to 3, for fruits; 8 to 12 harvests for vegetables; and 2 to 4 harvests, for fruits before the completion of the growth cycle of the ensat plant (i.e. harvesting).

(f) Ensat-based farming system could sustain the highest population density on limited land, since 15 to 25 plants are adequate to provide yearly supply of food for one person.

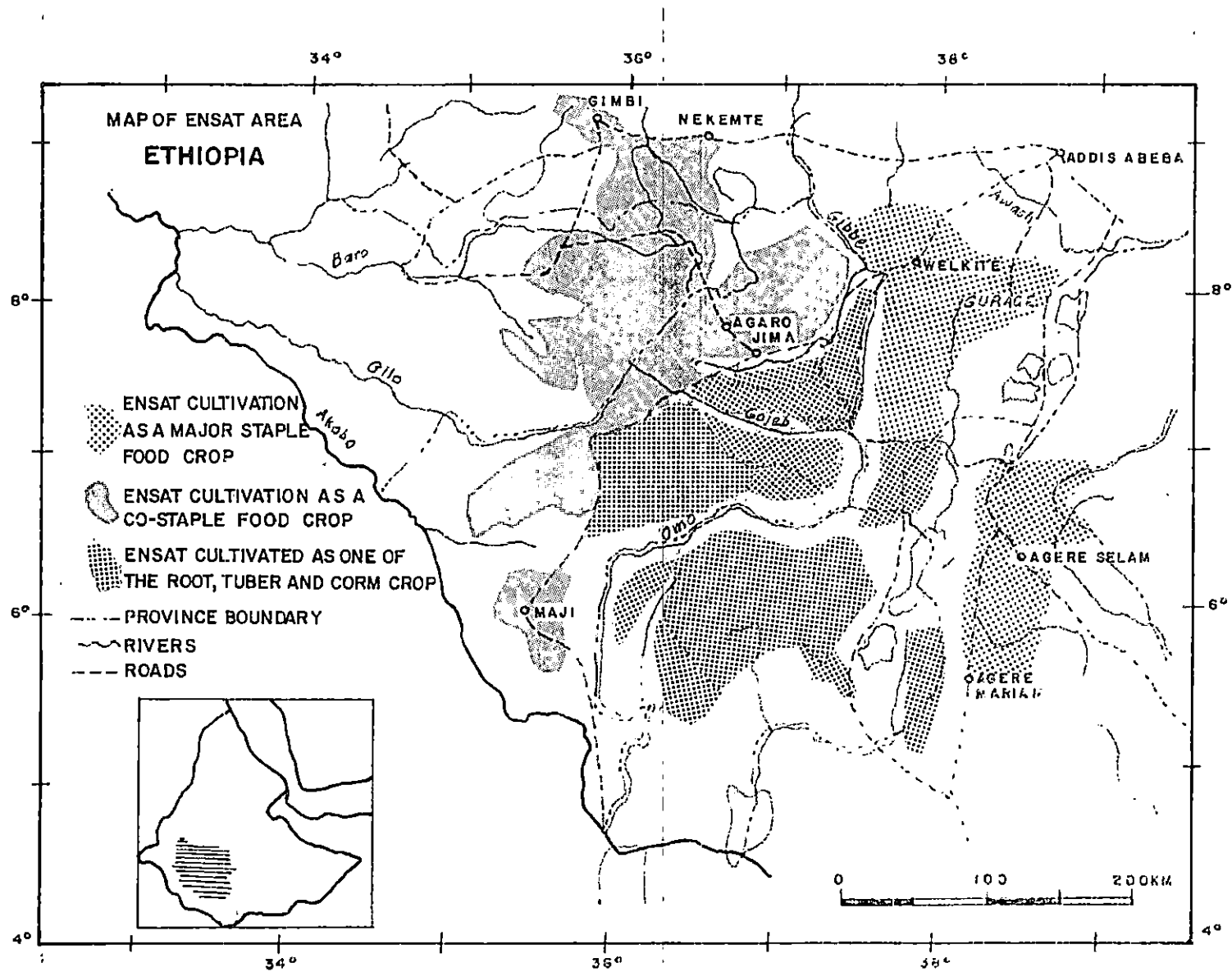


Fig. 3 Major areas of Ensete cultivation (adapted from Westphal 1975)

IV. Comments on Future Research Needs.

Ensat-based agriculture is quite diversified and a relatively more stable food and fiber production system. The ensat region is already among the most populated area. As discussed earlier, ensat-based farming systems comprise of multiple cropping such as cereals, tree crops, vegetables, fruits and raising of livestock.

Ensat-based sustainable agricultural production system, should be perceived as a dynamic concept that enhances the recycling of renewable resources and economic complementarity between sub-systems of production (i.e. crops, livestock, trees). Unlike other crop production systems, ensat-based farming has already integrated the basic components for the development of low-input agriculture. These include the continuous maintenance of soil fertility, through the use of manure, cereal/legume rotation, crop residue into the soil or as feed for livestock.

The following research thrust are identified as pathway to enhancing the development of ensat-based sustainable agricultural development:

1. Agronomic and socio-economic investigations.

The first and foremost research challenge should be to develop understanding, the extent of biological and economical complementarity that exist among various components that comprise this remarkable ensat-based traditional agriculture. In addition to regular agronomic research themes, the central research focus of ensat-based system should be the homestead environment (family decision, culture, etc), that galvanized ensat culture and agriculture. The re-cycling of renewable resources between crops, animals, forage legumes, livestock and the economic interdependability of this components is crucial to fully quantify and comprehend the system.

2. The development of technologies appropriate for processing ensat food and fiber.

It is recognized some research was pursued in this area during the last two decades. First, the orientation of research, should be to enhance the development of cottage industry at village level improving the efficiency for harvesting extracting food and fiber at village level. Food and fiber extraction from ensat plant is highly labour intensive. Improved machines or simple tools need to efficiently perform decortication, pulvering and liquid extraction from the ensat plant.

3. To standardize the fermentation process.

Through improved processing technology, the fermentation process of ensat for food can be standardized and its potential as staple carbohydrate food can be increased.

- (a) increase the ensat food recovery or harvest by standardizing current traditional practices of processing through improved techniques of processing.

Fermentation Studies.

- (b) Study of the different types of fermentation vats in regard to: nutrient recovery and optimal duration of fermentation.
- (c) Microbiological and biochemical studies of the fermentation process such as:

time-interval studies of the chemical changes during fermentation process; identification of the kinds of microflora associated with fermentation; improvement and standardization of the fermentation process using results obtained from microbiological and biochemical studies.

4. Ensat crop improvement.

Lessons learned in the past two decades suggest that, there is need to coordinate research efforts in following areas:

- (a) Maintenance of national living botanical collections and use uniform method for the characterization and classification of various clones.
- (b) Broadening the genetic base using botanical seeds and collection of clones (Fig. 4 propagation methods).
- (c) Screening ensat types resistance to bacterial wilt.
- (d) Selection and agronomic evaluation of elite clones for food and fiber yield.
- (e) Screening clones for drought resistance.

- (f) Study on ensat/intercropping and multiple cropping systems to develop agronomic packages.
- (g) Integration of livestock production to ensat agriculture.
- (h) Sustainance of soil fertility:
 - (i) determine efficient utilization of organic matter.
 - (ii) sources of organic matter.
 - (iii) soil-water-conservation, including control of soil erosion.

Table 1. Ecological distribution of some Ensete species.

Species	Ecological Distribution
<u>Ensete ventricosum</u> (Welw) Cheesman	In the cooler high elevation, and medium altitude regions; Grown as staple food and fiber crops only in Ethiopia. Wide spread also in Kenya, Uganda, Tanzania.
<u>E. gilletii</u> (Dewild) Cheesman	Native to West Africa from Sierra Leone, Nigeria, Cameroon to Angola, not cultivated either for food or fiber. It is adapted to drier locations than other Ensete species.
<u>E. homblei</u> Cheesman	Tiny species, distributed in Zaïre, Congo and Zambia. Adapted to dryland grass habitat.
<u>E. holstii</u> (K. Schum) Cheesman	East and Central Africa.
<u>E. prrieri</u> (Claverie)	Madagascar
<u>E. arnoldianum</u> (Dewild) Cheesman	Largely distributed in Tropical Africa (hybridization between <i>E. gilletii</i> and this spp was noticed).
<u>E. glaucum</u> (Roxb) Cheesman	Wide range of adaption from Burma to Philippine Islands.
<u>E. superbum</u> (Boxb.) Cheesman	India
<u>E. calospermum</u> (F.U. Mwell) Cheesman	Wide spread in the pacific, Fiji and New Guinea.

Table 1. Cont.

Species	Ecological Distribution
<u>E. fecundum</u> (Stapf) Cheesman	Relatively warm moist climate in East Africa, Uganda, etc.
<u>E. buchanani</u> (Baker) Cheesman	Highlands of Southern Africa.
<u>E. laurentii</u> (Dewild) Cheesman	Tropical moist Africa, Congo, etc.
<u>E. ruandense</u> (Dewild) Cheesman	Central Africa, adaptation to moist warm climate. Originally observed in Rwanda.
<u>E. rubronervatum</u> (Dewild) Cheesman	Central Africa, Rwanda, Congo, Ruwenzori.
<u>E. davyae</u> (Stapf) Cheesman	Southern Africa, Mozambique.
<u>E. bagshawei</u> (Rendle & Greaves) Cheesman	Eastern Africa, Uganda.
<u>E. wilsoni</u> (Tutcher) Cheesman	Southern China.
<u>E. schweinfurthii</u> (K. Schum et Warb) Cheesman	Distributed in Tropical Africa including Sudan.
<u>E. edule</u> (Horan) Cheesman	Often associated with <u>E. ventricosum</u> , some authors believe that it should be replaced by the latter spp. (Baker and Simmonds, 1953).

Source: Cheesman E.E. (1947).

Table 2. Basic morphological differences between Ensete and Musa Genera.

Morphological characteristics	Ensete	Musa
Pseudostem	Single, greatly enlarged (or dialated) at the base	Several in a cluster, nearly uniform and slender
Seed	6-11 mm in diameter	3-11 mm in diameter of wild bananas
Fruit	Not edible, contains several seeds	Fruit of tridiploid bananas is edible
Embryo	T-shape	Straight in wild banana seeds. Edible bananas pratically are seedless
Chromosome number	n = 9 (diploid = 18)	N = 10 and 11. Triploid, diploid, and tetraploid
Center of origin	Largely African-(East and West Africa) and some species from Asia.	Asia: Malay Peninsula, India, Philippines, etc.
Propagation	New shoots are induced vegetatively by removal of the central shoot from pseudosterm trunk. cultivated seeds if not scarified germinate slowly and erratically.	Normally, the species of this genus have stooling habit, where several shoots emerge voluntarily.

Table 3. Ensaf-Based Cropping Systems in the South and South-Western Ethiopia.

Vernacular name of clone	Characteristics	Region of Cultivation	Cropping Systems
Adow	Plants usually 5-10 m tall; pseudo-stem 4-5 m, much dilated at the base, 1.5-3.0 m in circumference, greenish yellow in colour; leaf 3-5 m long 0.5-1.4 m broad, mid-rib purple to brown in colour, borne on short petiole and arising from pseudostem somewhat in distinct cluster.	South of Addis Ababa, east of the Rift Valley including Eastern highlands of Sidamo provinces, constituting more than 60% of ensaf plantings in the region. The region varies from 1500 to 2800 m altitude with annual precipitation of 850 to 2000 mm and temperature ranges 16 to 24°C during most of the year. Ensaf is a major staple food crop.	Coffee from 1500 to 1900 m altitude, maize, <u>Eragrostis tef</u> , wheat, pulse crops, cabbage, and Irish potato at 2000 to 2500 m altitude. At high altitude, 2800 m, barley, tef and leafy vegetables, are grown. With increasing altitudes the cultivation of coffee as cash crop declines. Root crops (yams, taro) and barley cultivation increases.
Tuzuaa	Usually 5-8 m tall; pseudostem 3-5 m long, green with dark brown patches somewhat dilated 1.5-2.5 m in circumference at the base; leaves about 3.0 m long, 0.5-1.0 m broad; dark green, with red midrib also borne on short distance on the pseudostem.	Also south of Addis Ababa but west of the Rift Valley lakes in Ilyda-Kambata region. The region has 1800 to 2500 m altitude with annual precipitation between 750 to 1000 mm. The temperature range of the region is 20 to 26° C during most of the year. Equally other tuber and root crops are cultivated. Ensaf is a co-staple food crop.	Cereal crops-wheat, barley, tef, sorghum, maize. Tuber and root crops: taro, <u>Coleus edulis</u> , yam, potato, Pulses: pea, horse bean, etc. Vegetables: cabbage <u>Solanum dasyphyllum</u> and <u>S. nodiflorum</u> , and pepper. Several types of spices are also cultivated. Tobacco, cotton are also cultivated.
Ferezaa	4-7 m tall, pseudostem light green with heavy brown patches turning to dark brown as plant ages, 2-5 m long, much dilated at the base 1.6-2.8 m circumference; leaves light green, red to pale pink mid-rib; measures about 3.0 m long, 0.60 to 1.2 m broad, borne in distinct crown.	Location starting about 100 km south-west of Addis Ababa between Awash and Gibbe rivers. The cultivation of ensaf is highly developed by Gurage ethnic groups. There is great variation of ensaf clones in the region. Altitude in this region varies from 1800 to 2600 m with annual precipitation 750 to 1200 mm and temperature ranges 18 to 23° C. Ensaf is the major staple food crop.	Cereals: tef, wheat, Stimulants: coffee and <u>Catha edulis</u> (cha't) are grown. Pulses: chickpea, horse beans, lentil, bean, etc. are occasionally included. Vegetables: cabbage, onions, garlic, pumpkin are the common vegetables. Spices: hot pepper, sweet basil, coriander, etc. Tuber and root crops: potato, taro, yam, sweet potato are also cultivated.

Table 4. Average Yield of Fermented 'Kocho' from some Ensai Clones.

Clones	Plants per/ha	Yield ton/ha	Yield kg/ha	Region	Source
Adow ¹	2000	59.6	29.8	Easter highlands, Sidamo.	Taye B. (1984)
Mixture of three ³ clones	1600	43.7	27.3	Wolaita, Sodo.	Wolaita Agric. Div. Agron. Report 1979.
Mixture of ² several clones	2000	41.6	26.0	Emndiber, Gurague.	Teketel Makeso (1973).
Tuzume ¹	2000	44.4	22.2	Hydya/Kambatta	Taye B (1984)
Mixture of several clones ²	1600	67.2	42	Kombata	Teketel Makeso (1973)
Ferezael	2000	37.0	18.5	Woliso/Wolketie/Gurague	Taye B. (1984)

¹ Clones collected from indicated region, then vegetatively propagated for yield trials using randomized complete block design.

² Ensai yield assessments in different farm sites at indicated regions.

³ Trials conducted by Wolaita Agric. Development Unit. Yield represents of mixture clones.

Table 5. Ensat-based cropping systems in the different ecological zones.

Crops	Upper-high altitude zone 2500-3000 m	High altitude zone 2000-2400 m	Intermediate-altitude zone 1500-2000 m
Cereals	barley + wheat	wheat, tef, sorghum	maize, sorghum, tef
Pulses	horse bean, pea	horse bean, lentil, chickpea	chickpea, bean
Hort crops	cabbage, onions	garlic, peaches, onions	Tomato, papaya, citrus, banana
Cash crops			coffee, khat, cotton, sugarcane, tobacco
Root and tuber	potato	potato, coleus edulis	yam, taro, sweet potato
Oil crops	Brassica, Niger seed	Niger seed, linseed	Castor, sunflower, saff-flower
Spices		Thyme, fennel, sweet basil	Black cumin, pepper, corriander, capsicum, etc. ginger, cardamom
Other plants	Bamboo, for fences and construction	Bamboo, for fences and construction	<u>Erythrina</u> for nitrogen fixation.
Pasture	Relatively large size open pasture for common grazing of livestock	Limited size in between homstead	Limited, stall feeding of livestock.

Adapted from Westphal, 1975.

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