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## EAST AFRICAN STANDARD

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Finger millet grains — Specification and grading



EAST AFRICAN COMMUNITY

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HS 1008.20.00 [HS 1008.20.39]

## Foreword

Development of the East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in East Africa. It is envisaged that through harmonized standardization, trade barriers which are encountered when goods and services are exchanged within the Community will be removed.

In order to meet the above objectives, the EAC Partner States have enacted an East African Standardization, Quality Assurance, Metrology and Test Act, 2006 (EAC SQMT Act, 2006) to make provisions for ensuring standardization, quality assurance, metrology and testing of products produced or originating in a third country and traded in the Community in order to facilitate industrial development and trade as well as helping to protect the health and safety of society and the environment in the Community.

East African Standards are formulated in accordance with the procedures established by the East African Standards Committee. The East African Standards Committee is established under the provisions of Article 4 of the EAC SQMT Act, 2006. The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the private sectors and consumer organizations. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the procedures of the Community.

Article 15(1) of the EAC SQMT Act, 2006 provides that "Within six months of the declaration of an East African Standard, the Partner States shall adopt, without deviation from the approved text of the standard, the East African Standard as a national standard and withdraw any existing national standard with similar scope and purpose".

East African Standards are subject to review, to keep pace with technological advances. Users of the East African Standards are therefore expected to ensure that they always have the latest versions of the standards they are implementing.

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## Introduction

In the preparation of this East African Standard, the following sources were consulted extensively:

*Cereals Grading and Marking Rules, 2001*, Ministry of Agriculture, Government of India, Schedule II, *Grade Designation and Definition of Quality of Ragi*

CODEX STAN 169:1987 (Rev.1:1995), *Whole and decorticated pearl millet grains*

ISO 9648:1988, *Sorghum — Determination of tannin content published by the International Organization for Standardization (ISO)*

CODEX STAN 193:1995 (Rev.5:2009), *General Standard for Contaminants and Toxins in Foods*

CODEX STAN 228:2001 (Rev.1:2004), *General methods of analysis for contaminants*

CODEX STAN 230:2001 (Rev.1:2003), *Maximum levels for lead*

Codex Alimentarius website: [http://www.codexalimentarius.net/mrls/pestdes/jsp/pest\\_q-e.jsp](http://www.codexalimentarius.net/mrls/pestdes/jsp/pest_q-e.jsp)

USDA Foreign Agricultural Service website: <http://www.mrlidatabase.com>

USDA Agricultural Marketing Service website: <http://www.ams.usda.gov/AMSV1.0/Standards>

USDA Plant Inspectorate Service website: [http://www.aphis.usda.gov/import\\_export/plants](http://www.aphis.usda.gov/import_export/plants)

European Union: [http://ec.europa.eu/sanco\\_pesticides/public](http://ec.europa.eu/sanco_pesticides/public)

Assistance derived from these sources and others inadvertently not mentioned is hereby acknowledged.

This standard has been developed to take into account:

- the needs of the market for the product;
- the need to facilitate fair domestic, regional and international trade and prevent technical barriers to trade by establishing a common trading language for buyers and sellers.
- the structure of the CODEX, UNECE, USA, ISO and other internationally significant standards;
- the needs of the producers in gaining knowledge of market standards, conformity assessment, commercial cultivars and crop production process;
- the need to transport the product in a manner that ensures keeping of quality until it reaches the consumer;
- the need for the plant protection authority to certify, through a simplified form, that the product is fit for crossborder and international trade without carrying plant disease vectors;

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## Finger millet grains — Specification and grading

### 1 Scope

This East African Standard specifies the quality and grading requirements and methods of test for finger millet grains of varieties (cultivars) grown from *Eleusine coracana* (L.) Gaertner intended for human consumption, i.e., ready for its intended use as human food, presented in packaged form or sold loose from the package directly to the consumer. It does not apply to other products derived from finger millet grains.

### 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 605, *Pulses — Determination of impurities, size, foreign odours, insects, and species and variety — Test methods*

ISO 711, *Cereals and cereal products — Determination of moisture content (Basic reference method)*

ISO 712, *Cereals and cereal products — Determination of moisture content — Routine reference method*

ISO 5223, *Test sieves for cereals*

ISO 6639-1, *Cereals and pulses — Determination of hidden insect infestation — Part 1: General principles*

ISO 6639-2, *Cereals and pulses — Determination of hidden insect infestation — Part 2: Sampling*

ISO 6639-3, *Cereals and pulses — Determination of hidden insect infestation — Part 3: Reference method*

ISO 6639-4, *Cereals and pulses — Determination of hidden insect infestation — Part 4: Rapid methods*

ISO 13690, *Cereals, pulses and milled products — Sampling of static batches*

ISO 16050, *Foodstuffs — Determination of aflatoxin B<sub>1</sub>, and the total content of aflatoxin B<sub>1</sub>, B<sub>2</sub>, G<sub>1</sub> and G<sub>2</sub> in cereals, nuts and derived products — High performance liquid chromatographic method*

CAC/RCP 1, *Recommended international code of practice — General principles of food hygiene*

EAS 38, *Labelling of prepackaged foods — Specification*

EAS 79, *Cereals and pulses as grain — Methods of sampling*

EAS 217, *Methods for the microbiological examination of foods*

ISO 22000:2005, *Food safety management systems — Requirements for any organization in the food chain*

OIML R87:2004, *Quantity of product in prepackages*

### 3 Definitions and description

For the purpose of this East African Standard, the following definitions shall apply.

#### 3.1

##### **finger millet grain**

the dried grain having the characteristics of the species *Eleusine coracana* (L.) Gaertner

#### 3.2

##### **whole grains**

these are grains of finger millet obtained after proper threshing with no mechanical treatment

#### 3.3

##### **foreign matter**

any extraneous matter than other food grains comprising of

- (a) "Inorganic matter" includes metallic pieces, dust, sand, gravel, stones, dirt, pebbles, lumps or earth, clay, mud and animal filth etc;
- (b) "Organic matter" consisting of husk, straws, weeds and other inedible grains etc.

#### 3.4

##### **other edible grains**

any edible grains (including oil seeds) other than the one which is under consideration

#### 3.5

##### **damaged grains**

grains that are sprouted or internally damaged as a result of heat, microbe, moisture or weather viz., ergot affected grains and karnal bunt grains

#### 3.6

##### **immature and shrivelled grains**

grains that are not properly developed

#### 3.7

##### **weevilled grains**

grains that are partially or wholly bored by insects injurious to grains but does not include germ eaten grains and egg spotted grains

#### 3.8

##### **poisonous, toxic and/or harmful seeds**

any seed which if present in quantities above permissible limit may have damaging or dangerous effect on health, organoleptic properties or technological performance such as Jimson weed — datura (*D. fastuosa* Linn and *D. stramonium* Linn.) corn cokle (*Agrostemma githago* L., *Machai Lallium remulenum* Linn.) Akra (*Vicia* species), *Argemone mexicana*, Khesari and other seeds that are commonly recognized as harmful to health

### 4 Essential composition and quality factors

#### 4.1 General quality requirements

4.1.1 Finger millet shall meet the following general requirements/limits as determined using the relevant standards listed in Clause 2:

- a) shall be the dried mature grains of *Eleusine coracana* (L.) Gaertner;
- b) be sweet, hard, clean, wholesome, uniform in size, shape, colour and in sound merchantable condition;
- c) shall be safe and suitable for human consumption;

- d) shall be free of pests, live animals, animal carcasses, animal droppings, fungus infestation, added colouring matter, moulds, weevils, obnoxious substances, discoloration and all other impurities except to the extent indicated in this standard and must meet any other phytosanitary requirements specified by the importing country authority;
- e) shall be free from filth (impurities of plant and animal origin including insects, rodent hair and excreta) in amounts that represent a hazard to human health;
- f) shall be free from toxic or noxious seeds viz. *Crotalaria* (*Crotalaria* spp.), Corn cockle (*Agrostemma githago* L.), Castor bean (*Ricinus communis* L.), Jimson weed (*Datura* spp.), *Argemone mexicana*, Khesari and other seeds that are commonly recognized as harmful to health;
- g) shall be free from abnormal flavours, obnoxious smell and discolouration.
- h) shall be free from micro-organisms and substances originating from micro-organisms or other poisonous or deleterious substances in amounts that may constitute a hazard to human health.

**4.1.2** Finger millet grains shall be in form of well-filled seeds of uniform colour.

**4.1.3** Ergot affected grains shall not exceed 0.05 per cent by weight in damaged grains.

**4.1.4** If finger millet grains are presented in bags, the bags shall also be free of pests and contaminants. In addition the pearl millet grains shall comply with any conditions set by the importing country authority.

**4.1.5** If finger millet grains are rejected because pests or contaminants are found in inspected samples, the finger millet grains are not to be re-presented for inspection unless they have been treated or cleaned.

**4.1.6** Blending of rejected finger millet grains is not permitted as a treatment for insect infestation or as a method of cleaning for contaminants for which there is a nil tolerance

**4.1.7** Brushing the outside of bags is not permitted as a remedy to remove pests or contaminants.

## **4.2 Classification**

Finger millet shall be classified into four grades on the basis of the tolerable limits established in Table 1 which shall be additional to the general requirements set out in this standard.

### **4.3 Unclassified finger millet**

Shall be finger millet which do not fall within the requirements of Grades 1, 2, 3 and 4 of this standard but are not rejected finger millet.

### **4.4 Reject grade finger millet**

This comprises finger millet grains which have objectionable odour, off flavour, living insects or which do not possess the quality characteristics specified in Table 1. They cannot satisfy the conditions of unclassified finger millet grains and shall be classified as reject finger millet grains and shall be condemned as unfit for human consumption.

Table 1 — Specific requirements for finger millet grains

Characteristic		Grade				Method of test
		1	2	3	4	
Foreign matter, whole grains, % by mass, <i>max.</i>	Organic	0.10	0.25	0.50	0.75	ISO 605
	Inorganic	Nil	0.10	0.25	0.25	
Other edible grains, % by mass, <i>max.</i>		1.0	1.5	2.0	4.0	
Damaged grain, % by mass, <i>max.</i>		1.0	2.0	3.0	5.0	
Immature and shrivelled, % by mass, <i>max.</i>		2.0	3.0	4.0	4.0	
Weevilled grains per cent by count		0.1	0.2	0.3	0.5	
Moisture content		12.0	12.0	13.0	14.0	
Crude protein, % by dry mass basis, <i>min</i>		8.0				EAS 82
<b>Fat content, % by dry mass basis</b>		3.5 to 6.0				ISO 5986:1983
Tannin content, % by mass, <i>max.</i>		0.5				Annex A
Appearance: brown, white or green		Buyer preference				Undefined
<b>Crude fibre, % by dry mass basis:</b>		Range: 3.0 to 4.5				ISO 5498:1981
NOTE <b>Foreign matter</b> is mineral or organic matter (dust, twigs, seedcoats, seeds of other species, dead insects, fragments, or remains of insects, other impurities of animal origin). Finger millet grains shall have not more than 1% extraneous matter of which not more than 0.25% shall be mineral matter and not more than 0.10% shall be dead insects, fragments or remains of insects, and/or other impurities of animal origin.						

## 5 Contaminants

### 5.1 Heavy metals

Finger millet grains shall be free from heavy metals in amounts which may represent a hazard to health. If present, they shall not exceed the limits established in Table 2.

Table 2 — Heavy metal contaminant limits

Parameter		Limit	Test method
i)	Arsenic (As), ppm max.	0.10	EAS 101 or EAS 100
ii)	Copper (Cu), ppm max.	2.0	EAS 100
iii)	Lead (Pb), ppm max.	0.10	EAS 100
iv)	Cadmium (Cd), ppm max.	0.02	EAS 100
v)	Mercury (Hg), ppm max.	0.01	EAS 100

### 5.2 Pesticide residues

Finger millet grains shall comply with those maximum pesticide residue limits established by the Codex Alimentarius Commission for this commodity. Annex E provides current MRLs for the USA, EU and Codex markets.

### 5.3 Mycotoxin and chemical limits

Finger millet grains shall comply with those maximum mycotoxin limits established by the Codex Alimentarius Commission for this commodity.

**5.3.1** Uric acid shall not exceed 100 milligrams per kilogram.

**5.3.2** Total aflatoxin levels in finger millet grains for human consumption shall not exceed 10 ppb with B<sub>1</sub> not exceeding 5 ppb when tested according to ISO 16050.

## 5.4 Environment

Finger millet shall be produced, processed and handled under conditions complying with the stipulations of relevant environmental regulations and therefore conform to cleaner production technological practices.

## 6 Hygiene

**6.1** It is recommended that the produce covered by the provisions of this Standard be prepared and handled in accordance with the appropriate sections of CAC/RCP 1, ISO 22000, and other relevant Codex texts such as Codes of Hygienic Practice and Codes of Practice.

**6.2** The produce should comply with any microbiological criteria established in accordance with CAC/GL 21.

**6.3** To the extent possible in good manufacturing practice, the products shall be free from objectionable mater.

**6.4** When tested by appropriate standards of sampling and examination listed in Clause 2, the products:

- shall be free from microorganisms in amounts which may represent a hazard to health and shall not exceed the limits stipulated in Table 3;
- shall be free from parasites which may represent a hazard to health; and
- shall not contain any substance originating from microorganisms in amounts which may represent a hazard to health.

**Table 3 — Microbiological limits for finger millet grains**

	Type of micro-organism	Limits	Test method
i)	Yeasts and moulds, max. per g	10 <sup>2</sup>	EAS 217
ii)	<i>S.aureus</i> per 25 g	Nil	
iii)	<i>E. Coli</i> , max. per g	Nil	
iv)	<i>Salmonella</i> , max. per 25 g	Nil	

## 7 Packaging

**7.1** Finger millet grains shall be packed in gunny bags/jute bags, poly woven bags, poly pouches, cloth bags or other suitable packages which shall be clean, sound, free from insect, fungal infestation and the packing material shall be of food grade quality.

**7.2** Finger millet grains shall be packed in containers which will safeguard the hygienic, nutritional, technological and organoleptic qualities of the products.

**7.3** The containers, including packaging material, shall be made of substances which are safe and suitable for their intended use. They shall not impart any toxic substance or undesirable odour or flavour to the product.

**7.4** The net weight of the finger millet grains in a package shall comply with OIML R87.

**7.5** Each package shall contain finger millet grains of the same type and of the same grade designation.

**7.6** Each package shall be securely closed and sealed.

## 8 Marking or labelling

8.1 In addition to the requirements in EAS 38, each package shall be legibly and indelibly marked with the following:

- i) product name as “Finger Millet Grains”;
- ii) variety;
- iii) grade;
- iv) name, address and physical location of the manufacturer/ packer/importer;
- v) lot/batch/code number;
- vi) net weight, in g/kg;
- vii) the declaration “Food for Human Consumption”;
- viii) storage instruction as “Store in a cool dry place away from any contaminants”;
- ix) crop year;
- x) packing date;
- xi) expiry date or best before \_\_\_\_\_ month \_\_\_\_\_ year;
- xii) a declaration of the product lifespan;
- xiii) instructions on disposal of used package;
- xiv) country of origin;
- xv) a declaration on whether the finger millet was genetically modified or not.

8.2 A declaration of any inaccurate information in marking/labelling is prohibited and shall be punishable by law under the statutes of the Partner States.

8.3 The authorized packer shall observe all instructions regarding testing, grading, packing, marking, sealing and maintenance of records applicable to the product.

## 9 Sampling

Sampling shall be done in accordance with the EAS 79/ISO 13690.

Draft



Mature finger millet in field



Finger millet grains



Mature finger millet in field



Finger millet grains



Finger millet plants in field

Draft

**Annex A**  
(normative)

**Determination of impurities, size, foreign odours, insects, and species and variety**

These shall be determined in accordance with ISO 605, *Pulses — Determination of impurities, size, foreign odours, insects, and species and variety — Test methods*

Draft for comments only — Not to be cited as East African Standard

**Annex B**  
(normative)

**Determination of moisture content**

Moisture content shall be determined in accordance with the following standards:

- ISO 711, *Cereals and cereal products — Determination of moisture content (Basic reference method)*
- ISO 712, *Cereals and cereal products — Determination of moisture content — Routine reference method*

Draft for comments only — Not to be cited as East African Standard

**Annex C**  
(normative)

**Finger millet grains — Determination of tannin content**

**C.1 Principle**

Extraction of tannins by shaking with dimethylformamide. After centrifuging, addition of ferric ammonium citrate and ammonia to an aliquot part of the supernatant liquid and spectrometric determination, at 525 nm, of the absorbance of the solution thus obtained. Determination of the tannin content using a calibration curve prepared using tannic acid.

**C.2 Reagents**

All reagents shall be of analytical grade. Water used shall be of distilled quality according to EAS 123 or water of at least equivalent purity.

**C.2.1 Tannic acid, 2 g/l solution**

Use Merck reference 773 tannic acid product that is commercially available.

**C.2.2 Ammonia solution of 8.0 g/l NH<sub>3</sub>.**

**C.2.3 Dimethylformamide, 75 % (v/v) solution.**

Introduce 75 ml of dimethylformamide into a 100 ml volumetric flask. Dilute with water, allow to cool and make up to the mark.

NOTE Dimethylformamide may be harmful to health when inhaled or allowed to come into contact with the skin. It is also irritating to the eyes.

**C.2.4 Ferric ammonium citrate**

Use ferric ammonium citrate having an iron content between 17 % (m/m) and 20 % (m/m), 3.5 g/l solution prepared 24 h before use.

Since the iron content has an influence on the results, this content shall be respected imperatively.

**C.3 Apparatus**

**C.3.1 Mechanical crusher**, capable of producing particles, which pass completely through the sieve (C.3.2).

**C.3.2 Sieve** having aperture of size 0.5 mm.

**C.3.3 Centrifuge**, capable of producing a centrifugal acceleration of 3 000g (3 000 x 9.81 m/s<sup>2</sup>).

**C.3.4 Centrifugal tubes**, with a capacity of approximately 50 ml, provided with stoppers ensuring hermetic sealing.

**C.3.5 Mechanical stirrer**, with a reciprocating motion, or magnetic stirrer.

**C.3.6 Mechanical shaker** for test tubes.

**C.3.7 Spectrometer**, with cells 10 mm thick, permitting measurements at 525 nm.

**C.3.8 Pipettes** of 1 ml, 5 ml and 20 ml capacity.

**C.3.9 Graduated pipettes** of 5 ml and 10 ml capacity.

**C.3.10** Test tubes 140 mm x 14 mm.

**C.3.11** Volumetric flasks of 20 ml capacity.

#### **C.4 Sampling**

Sampling shall be carried out in accordance with EAS 79.

Finger millet grains intended for determination of tannin content may be conserved for seven months, protected from light and should preferably be dried.

#### **C.5 Preparation of test sample**

Remove any extraneous matter other than finger millet from the laboratory sample and crush the sample in the mechanical crusher (C.3.1) so as to reduce it to particles of a size, which will pass completely through the sieve (C.3.2). Mix thoroughly.

The tannins in crushed products oxidize rapidly and therefore it is recommended to proceed immediately with the analysis after crushing.

**NOTE** The crushed product may be conserved at most for several days, protected from light, and should preferably be dried.

#### **C.6 Procedure**

##### **C.6.1 Water content of the sample**

Determine the water content of the sample according to ISO 9648 (see clause 2).

##### **C.6.2 Test portion**

Introduce about 1 g of the test sample (Clause C.5) weighed to the nearest 1 mg into a centrifuge tube (C.3.4).

##### **C.6.3 Determination**

**C.6.3.1** using pipette (C.3.8) introduce 20 ml of the dimethylformamide solution (C.2.3) into the centrifuge tube. Stopper the tube hermetically and stir it for 60 min  $\pm$  1 min using the stirrer (C.3.5). Then centrifuge for 10 min using an acceleration of 3 000 g.

**C.6.3.2** Remove 1 ml of the supernatant liquid (C.6.3.1) using a pipette (C.3.8) and introduce it into a test tube (C.3.10). Successively add 6 ml of water and 1 ml of the ammonia solution (C.2.2) using a pipette, and then shake for a few seconds using the shaker (C.3.6).

**C.6.3.3** Remove 1 ml of the supernatant liquid (C.6.3.1) with a pipette (C.3.8) and introduce it into a test tube (C.3.10). Successively add 5 ml of water and 1 ml of the ferric ammonium citrate solution (C.2.4) using a pipette, shake for a few seconds using the shaker (C.3.6), then add 1 ml of the ammonia solution (C.2.2) using a pipette and shake again for a few seconds using the shaker (C.3.6).

**C.6.3.4** Transfer the solutions obtained in C.6.3.2 and C.6.3.3 into measuring cells and, 10 min  $\pm$  1 min after the end of the operations carried out in C.6.3.2 and C.6.3.3 measure the absorbance, at 525 nm, using the spectrometer (C.3.7) against a water blank. The result is the difference between the two absorbance s.

##### **C.6.4 Number of determinations**

Carry out two determinations on test portions taken from the same test sample.

**C.6.5 Establishment of the calibration curve**

Determine the calibration curve on the day of the determination as indicated in a) to c).

- a) Prepare six 20 ml volumetric flasks (C.3.11) and using a graduated pipette (C.3.9), add to them respectively 0 ml, 1 ml, 2ml, 3ml, 4ml, and 5 ml of the tannic acid solution (C.2.1) make up to the mark with the dimethylformamide solution (C.2.3). The calibration scale thus obtained corresponds to tannic acid contents of 0 mg/ml, 0.1mg/ml, 0.2 mg/ml, 0.3 mg/ml, 0.4 mg/ml and 0.5 mg/ml respectively.
- b) Pipette into test tubes (C.3.10) 1 ml of each of these solutions and add successively using a pipette (C.3.8), 5ml of water and 1 ml of the ferric ammonium citrate solution (C.2.4) and shake for a few seconds using the shaker (C.3.6). Then add 1 ml of ammonia solution (C.2.2) and shake again for a few seconds using the shaker (C.3.6).

Transfer the solutions thus obtained into measuring cells and after 10 min ± 1 min measure the absorbances at 525 nm, using the spectrometer against water blank.

- c) Plot the calibration curve, using the absorbance values as the ordinate and the corresponding concentrations of tannic acid on the calibration scale (a) as the abscissa, in milligrams per millilitre.

The curve should not pass through the origin and shall not be corrected for the zero of the scale.

**C.7 Expression of results**

The tannin content, expressed as a percentage by mass of tannic acid in relation to the dry matter, is given as

$$\frac{2C}{m} \times \frac{100}{100 - H}$$

where

*C* is the tannic acid concentration, in milligrams per millilitre, of the test solution, read from the calibration curve (C.6.5.c).

*m* is the mass in grams, of the test portion (C.6.2).

*H* is the water content of the sample, as a percentage by mass (C.6.1).

Take as the result, the arithmetic mean of the two determinations provided that the requirements for repeatability, using linear interpolation are satisfied.

## Annex D (normative)

### Finger millet — Fact sheet

#### D.1 Overview

##### D.1.1 Botanical name

*Eleusine coracana* (L.) Gaertner

##### D.1.2 Common names

*Afrikaans (and Dutch)*: vogel gierst

*Arabic*: tailabon

*Bantu*: bule

*English*: finger millet, African millet; koracan

*French*: petit mil, eleusine cultivée, coracan, koracan

*German*: Fingerhirse

*Swahili*: wimbi, ulezi

*Ethiopia*: dagussa (Amharic/Sodo), tokuso (Amharic), barankiya (Oromo)

*India*: ragi

*Kenya*: wimbi (kiswahili), mugimbi (Kikuyu)

*Malawi*: mawere, lipoko, usanje, khakwe, mulimbi, lupodo, malesi, mawe

*Nepal*: koddo

*The Sudan*: tailabon (Arabic), ceyut (Bari)

*Tanzania*: mwimbi, mbege

*Uganda*: bulo

*Zambia*: kambale, lupoko, mawele, majolothi, amale, bule

*Zimbabwe*: rapoko, zviyo, njera, rukweza, mazhovole, uphoko, poho

##### D.1.3 Description

Finger millet is a tufted annual growing 40-130 cm tall, taking between 2.5 and 6 months to mature. It has narrow, grass like leaves and many tillers and branches. The head consists of a group of digitately arranged spikes.

It is a tetraploid.

##### D.1.4 Distribution

Finger millet derives from the wild diploid *Eleusine africana*. There is archaeological evidence that before maize was introduced it was a staple crop of the southern Africa region. Today it is found throughout eastern and southern Africa and is the principal cereal grain in Uganda, where it is planted on more than 0.4 million hectares (especially in northern and western regions), as well as in northeastern Zambia. It is also an important backup "famine food" as far south as Mozambique.

Finger millet does not appear to have been adopted in ancient Egypt, and it is said to have reached Europe only about the beginning of the Christian era. However, it arrived in India much earlier, probably more than 3,000 years ago, and now it is an important staple food in some places, particularly in the hill country in the north and the south.

##### D.1.5 Cultivated varieties

Numerous cultivars have been recognized in India and Africa, consisting of highland and lowland forms, dryland and irrigation types, grain and beer types, and early- and late-maturing cultivars. By and large, there are highland races and lowland races—each adapted to its own climate.

### D.1.6 Environmental requirements

#### D.1.6.1 Daylength

Finger millet is a short-day plant, a 12-hour photoperiod being optimum for the best-known types. It has been successfully grown in the United States as far north as Davis, California (with considerable problems of photoperiod sensitivity), and it is widely grown in the Himalayas (30°N latitude); however, it is mainly produced within 20°N and 20°S latitude. Daylength-neutral types probably exist.

#### D.1.6.2 Rainfall

It requires a moderate rainfall (500-1,000 mm), well distributed during the growing season with an absence of prolonged droughts. Dry weather is required for drying the grain at harvest. In drier areas with unreliable rainfall, sorghum and pearl millet are better suited. In wetter climates, rice or maize is preferable.

#### D.1.6.3 Altitude

Most of the world's finger millet is grown at intermediate elevations, between 500 and 2,400 m. Its actual altitude limits are unknown.

#### D.1.6.4 Low temperature

The crop tolerates a cooler climate than other millets. For an African native, this crop is surprisingly well adapted to the temperate zones.

#### D.1.6.5 High temperature

Finger millet thrives under hot conditions. It can grow where temperatures are as high as 35°C. In Uganda, the crop grows best where the average maximum temperature exceeds 27°C and the average minimum does not fall below 18°C.

#### D.1.6.6 Soil type

The crop is grown on a variety of soils. It is frequently produced on reddish-brown lateritic soils with good drainage but reasonable water-holding capacity. It can tolerate some waterlogging. It seems to have more ability to utilize rock phosphate than other cereals do.

### D.2 Status

Finger millet (*Eleusine coracana*) is hardly "lost." Indeed, it is one of the few special species that currently support the world's food supplies. This African native probably originated in the highlands of Uganda and Ethiopia, where farmers have been growing it for thousands of years. In parts of eastern and southern Africa as well as in India, it became a staple upon which millions depend. And its annual world production is at least 4.5 million tons of grain, of which Africa produces perhaps 2 million tons.

For all its importance, however, finger millet is grossly neglected both scientifically and internationally. Compared to the research lavished on wheat, rice, and maize, for instance, it receives almost none. Most of the world has never heard of it, and even many countries that grow it have left it to languish in the limbo of a "poor person's crop," a "famine food," or, even worse, a "birdseed", as is the case in the USA.

Further, in recent years this neglected crop has started an ominous slide that could propel it to oblivion even in Africa. In fact, it has declined so rapidly in southern Africa, Burundi, Rwanda, and Zaire, for instance, that some people predict that in a few years it will be hard to find—even where until recently it was the predominant cereal. In those areas it clings to existence only in plots that are grown for use on feast days and other occasions demanding prestige fare.

The world's attitude towards finger millet must be reversed. Of all major cereals, this crop is one of the most nutritious. Indeed, some varieties appear to have high levels of methionine, an amino acid

lacking in the diets of hundreds of millions of the poor who live on starchy foods such as cassava and plantain. Outsiders have long marveled at how people in Uganda and southern Sudan could develop such strapping physiques and work as hard as they do on just one meal a day. Finger millet seems to be the main reason.

This crop has many other advantages as well. Its grain tastes better than most; Africans who know it usually prefer finger millet over all others. The plant is also productive and thrives in a variety of environments and conditions. Moreover, its seeds can be stored for years without insect damage, which makes them lifesavers for famine-prone areas.

Given all these qualities, it is perhaps hard to understand why finger millet is being rejected. But the reason is simple. People are giving it up in favor of maize, sorghum, and especially cassava because producing finger millet takes a lot of work.

The truth is that finger millet, as produced at present, demands a dedication to drudgery that, given a choice, few people are willing to invest. Part of the terrible toil is in weeding the fields, part in handling the harvest, and part in processing the grain.

### **D.3 Prospects**

Even though finger millet is declining in the heartland where 30 years ago it was the major crop of the land, all is not lost. Indeed, if immediate attention is given, the impediments causing the decline will probably be eliminated. In fact, there are already signs that the slide may be bottoming out. Prices paid for finger millet have risen dramatically in some places, and the crop is enjoying something of a resurgence—and a highly profitable one at that. In Kenya, for instance, the grain currently sells at more than twice the price of sorghum and maize. In Zimbabwe, too, the government offers an attractive producer price, which has tended to slow the decline. And Uganda's most recent statistics indicate that finger millet still occupies 50 percent of its cereal area.

#### **D.3.1 Africa**

If this crop is given proper attention, it has the following possibilities within Africa.

##### **D.3.1.1 Humid areas**

Excellent prospects. Certain varieties are adapted to heat, humidity, and tropical conditions. (Finger millet was once the principal staple for people in southern Sudan and northern Uganda, for instance.) Given research, recognition, and sympathetic policies, production could expand dramatically.

Finger millet seedheads look like "hands" with the grain contained in the "digits," hence the name. Some of the hands are curled into "fists." The crop is especially appreciated by the peoples in eastern and northern Uganda. To them, it has a high social value. They traditionally hold celebrations for the new harvest, and they serve finger millet bread to visitors and neighbors whom they want to impress. In the Uganda region, however, the people prefer finger millet in the form of hot porridge served with either sugar or banana juice.

##### **D.3.1.2 Dry areas**

Fair prospects. Finger millet is not as drought tolerant as pearl millet or even sorghum, but it could play a much greater role in savanna areas that get at least moderate rainfall.

##### **D.3.1.3 Upland Areas**

Excellent prospects. Certain finger millet landraces are fully adapted to highland conditions. In Africa the crop is usually grown at altitudes between 1,000 and 2,000 m and in Nepal it is grown at altitudes up to at least 2,400 m.



Finger millet is grown throughout eastern and southern Africa, but especially in the subhumid uplands of Uganda, Kenya, Tanzania, Malawi, Zaire, Zambia, and Zimbabwe. The crop originated somewhere in the area that today is Uganda.

### D.3.2 Other regions

Finger millet is certainly not being abandoned in Asia. Indeed, India's national yields have increased 50 percent since 1955. Moreover, in Nepal, the finger millet area is expanding at the rate of 8 percent per year. Any international efforts to promote and improve the plant appear to be as beneficial to Asia as to Africa.

NOTE Most of the increase occurred between 1955 and 1975 and resulted from genetic improvement of India's traditional landraces. Subsequent increases were due to crosses between those and new strains introduced from Africa.

NOTE In Nepal the crop has a special niche: during monsoon rains, it continues growing well, even when the soil is almost waterlogged and where the nutrients have been leached out by the daily downpours.

This high-methionine grain might also be beneficial for use in weaning foods and in many other cereal products in parts of the world (Latin America and North America, for instance) where it is now largely ignored.

### D.4 Uses

This is a versatile grain that can probably be used in dozens of types of foods, including many that are quite unlike its traditional ones. Its several major uses include the following:

- Porridge. The small grains—which are usually brown but occasionally white—are commonly boiled into a thick porridge.
- Bread. Some finger millet is ground into flour and used for bread and various other baked products. All are relished for their flavor and aroma.
- Malt. Malted finger millet (the sprouted seeds) is produced as a food in a few places. It is nutritious, easily digested, and is recommended particularly for infants and the elderly.

- Beverages. Much finger millet in Africa is used to make beer. Its amylase enzymes readily convert starch to sugar. Indeed, finger millet has much more of this "saccharifying" power than does sorghum or maize; only barley, the world's premier beer grain, surpasses it. In Ethiopia, finger millet is also used to make arake, a powerful distilled liquor.
- Fodder. Finger millet straw makes good fodder—better than that from pearl millet, wheat, or sorghum. It contains up to 61 percent total digestible nutrients.
- Popped Products. Finger millet can be popped. It is widely enjoyed in this tasty form in India.

## D.5 Nutrition

The grain's protein content (7.4 percent) is comparable to that of rice (7.5 percent). However, it shows considerable variation, and at least one Indian cultivar contains as much as 14 percent protein.

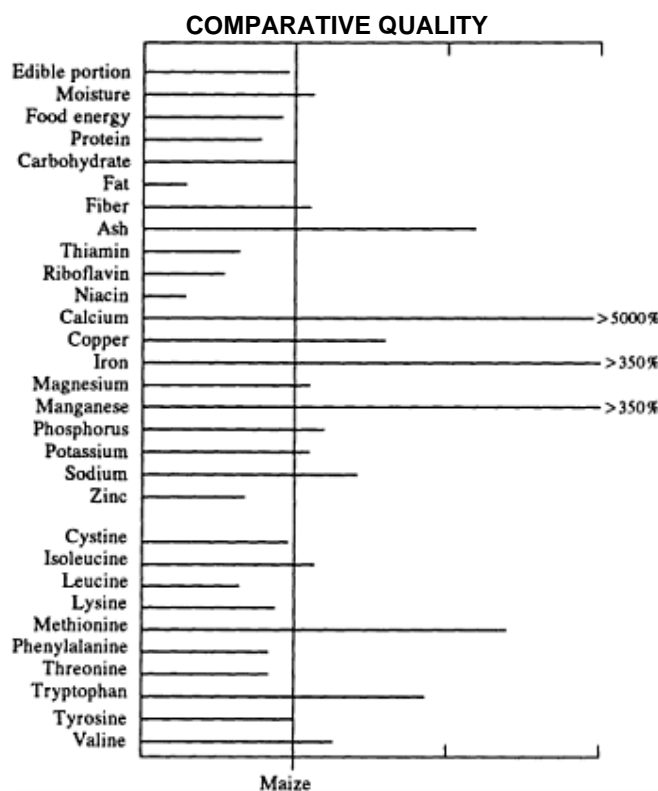
The main protein fraction (eleusin) has high biological value, with good amounts of tryptophan, cystine, methionine, and total aromatic amino acids (Total aromatic acids" is the combination of phenylalanine and tyrosine). All of these are crucial to human health and growth and are deficient in most cereals. For this reason alone, finger millet is an important preventative against malnutrition. The methionine level—ranging around 5 percent of protein—is of special benefit, notably for those who depend on plant foods for their protein.

Finger millet is also a rich source of minerals. Some samples contain 0.33 percent calcium, 5-30 times more than in most cereals. The phosphorus and iron content can also be high.

### Nutrient composition

Main Components		Essential Amino Acids	
Edible portion (g)	95	Cystine	1.7
Moisture (g)	12	Isoleucine	4.0
Food energy (Kc)	334	Leucine	7.8
Protein (g)	7.3	Lysine	2.5
Carbohydrates (g)	74	Methionine	5.0
Fats (g)	1.3	Phenylalanine	4.1
Fiber (g)	3.2	Threonine	3.1
Ash (g)	2.6	Tryptophan	1.3
Vitamin A (RE)	6	Tyrosine	4.1
Thiamin (mg)	0.24	Valine	6.4
Riboflavin (mg)	0.11		
Niacin (mg)	1.0		
Vitamin C (mg)	1		
Calcium (mg)	358		
Chloride (mg)	84		
Copper (mg)	0.5		
Iodine (µg)	10		
Iron (mg)	9.9		
Magnesium (mg)	140		
Manganese (mg)	1.9		
Molybdenum (µg)	2		
Phosphorus (mg)	250		
Potassium (mg)	314		
Sodium (mg)	49		
Zinc (mg)	1.5		

No single set of numbers can adequately convey the nutritional promise of a grain as variable as finger millet. The numbers in these pages should be taken with caution. The dozen or so measurements that have been reported generally agree on most of the different nutrients. However, protein contents ranging from 6 to 14 percent have been claimed. The levels of fat (1-1.4 percent) and food energy (323-350 Kc) that are normally given are fairly consistent and are about the same as in maize. However, in some samples they seem to be much higher. The situation regarding iron is somewhat similar. Most analyses give the figure as about 5 mg per 100 g. But there have been two reports of iron exceeding 17 mg.



Figures reported for the essential amino acids are generally consistent, but 3 percent methionine is commonly referred to in the literature. Possibly, this was based on degerminated flour. Even that figure is outstanding for a cereal grain. In this chart, we have compared whole-grain finger millet with the standard figures for maize. These are perhaps not fair comparisons, but they do accurately reflect the differences between the forms in which each food is normally eaten.

#### D.6 Agronomy

In Asia, finger millet is planted in rows and managed much like other cereals. But in Africa it is usually handled differently. Unlike maize, sorghum, or pearl millet—all of which are planted at individual stands in a rough seedbed—finger millet is traditionally planted in Africa by broadcasting its tiny seeds. This demands a very fine seedbed and means that the farmers must work hard and long, both to prepare the land and to weed the young plants.

Two crops a year are possible with early-maturing types.

#### D.7 Harvesting and handling

In most of Africa the crop is harvested by hand. Individual heads are cut off with a knife, leaving a few centimeters of stalk attached. These are piled in heaps for a few days, which fosters a fermentation whose heat and hydrolysis makes the seeds easier to thresh.

Finger millet seeds are so small that weevils cannot squeeze inside. In fact, its unthreshed heads resist storage pests so well they can be stored for 10 years or more without insect damage. (It is said that if kept dry the seed may remain in good condition for up to 50 years!)

Yields are variable but (compared to those of other grains in the area) are generally good. In Uganda, for example, a threshed yield of 1,800 kg per hectare is regarded as average. In India, on reasonable dryland sites, yields may run to about 1,000 kg per hectare, and on irrigated sites a normal average is more than 2,000 kg per hectare. Yields of 5,000-6,000 kg per hectare have been obtained under ideal irrigated conditions. Similar yields have been obtained in Nepal even under rainfed conditions.

## D.8 Limitations

As has been noted, the small size of the seeds is a serious drawback. It makes the crop difficult to handle at all stages.

Weeding is a particular problem. In Africa the dominant weed, a wild relative of the crop, looks so much like finger millet in its early stages that only skilled observers and close scrutiny can tell them apart. The problem is compounded by the practice of broadcasting seed. To weed the resulting jumbled stands, people must inspect every plant, even going through on hands and knees.

Finger millet is subject to bird predators—notably to the notorious quelea.

By and large, the plant suffers little from diseases and insects, but a ferocious fungal disease called "blast" can devastate whole fields.

Finger millet is almost entirely self-pollinating and crosses between different strains can be made only with difficulty. Until recently, genetic improvement was limited to pedigree-based selection. However, in Uganda a few plants with male sterility have now been discovered. These should ease the way to breeding methods in which different lines can be crossed without trouble.

Because the seeds are so small, it takes skill and much effort to convert finger millet into flour—particularly by hand. Even hammer mills have difficulty. They must be fitted with very fine screens and run at high speed. Recently, however, a special mill for millet has been devised.

## D.9 Next steps

If finger millet is ever to be rescued, now is the time. The key is to find ways to present its plight and promise to the public and politicians and to develop its markets. A few motivated individuals could do much here. Among helpful actions might be a pan-African finger millet conference, where researchers and others could compare methods used to grow it, prepare it, and sell it in the various nations. This meeting would provide the opportunity to exchange experiences and to begin the process of preparing papers, pamphlets, recipes, and perhaps a monograph. Another might be the establishment of a "finger millet action program" to share seeds and research results in the future. There might even be established a pan-African finger millet "SWAT" team to provide advice and stimulus to the countries where finger millet is now declining toward economic extinction.

Rescuing this crop may be easier than now seems probable. Lifestyles and eating habits may have changed, but in much of Africa people still appreciate finger millet. Subsistence farmers like finger millet also. Every seed sown can return between 200 and 500 seeds (other grain crops seldom go above 100 even under ideal conditions). And this crop has many uses. To those whose very lives and livelihoods depend on what they grow, its flexibility is vital.

Beyond Africa, finger millet should also be given a higher research priority. It is a good way to help the rural poor in parts of Asia. Much of the spectacular rise of wheat occurred in areas where irrigation could be used. Overcoming finger millet's yield constraints would, more importantly, benefit rainfed agriculture.

### Research needs

Research is needed on all aspects of this plant, which now is little known to scientists in general. ICRISAT is conducting research on it, but more effort is needed. Research operations might include those discussed below.

### Trials in new areas

Entrepreneurs in the United States as well as in Australia and other countries that specialize in cereal breeding could probably do much to benefit this crop. It is already grown in a small way in the United States. It grows well, but so far is used only for birdseed. Nonetheless, it might support a small

specialty grain industry for local and national food uses. And enlisting the country's outstanding cereal-science capabilities could perhaps transform this crop's potential worldwide.

### Farming Methods

As far as Africa is concerned, finger millet's greatest immediate needs lie not so much in plant breeding as in farming practices. Reducing the current drudgery involved with its production would bring the biggest and quickest benefits.

Surprisingly, techniques for making finger millet production less laborious can probably be employed rapidly and widely. For instance, planting the seed in rows would dramatically slash the need for weeding. One or two hoeings (or perhaps a layer of mulch) would eliminate most of the weeds with little further effort. To make this practical, however, a device is needed that can deliver small seed with precision. It would have to be easy to make and simple to use. Such devices do indeed exist but have not yet been introduced to finger millet farmers.

Examples of other types of farming practices worth exploring are the following:

- Minimum tillage seeding.
- Wide rows for water capture.
- Control of birds.
- Intercropping or undersowing with legumes. (The foliage from leguminous shrubs or ground cover may be especially helpful by supplying nitrogen to the crop.)
- Sowing or transplanting with other crops. (In Nepal, for instance, it is often planted with maize.)
- Weeding using animal power and other labor-saving techniques.
- Developing ox-drawn implements for planting, cultivating, harvesting, and threshing finger millet.

### Erosion control

In some parts of southern and eastern Africa finger millet has been abandoned because it "causes" severe soil erosion. In these areas, farmers typically clear forest from a hillside, burn it, and sow finger millet in the ashes. The tiny plants hold soil poorly, and it easily washes away. For such sites there is a need for alternative methods of erosion control. One example might be vetiver. Another is mulching with stubble from the previous crop.

On the other hand, other parts of Africa actually employ finger millet for erosion control. In fact, when broadcast—or even line sown—across the slope it is good for reducing erosion. Data from Zambia, for example, show that the plant prevents erosion more effectively than legumes do. Farmers in Nepal also report that finger millet "holds the soil."

### Plant breeding

In its genetic development as a crop, finger millet is about where wheat was in the 1890s. Many landrace types are known but have not been systematically evaluated, codified, or analyzed. Thus it is likely that the best-yielding, best-tasting, and best-handling types have not been isolated or created out of the massive gene pool. Since the 1890s, average yields of wheat have risen from about 500 kg per hectare to more than 4,000 kg per hectare; finger millet's could rise similarly and much more quickly.

Various finger millet landraces possess genes for blast resistance, robust growth, early vigor, large panicle size, high finger number and branching, and high-density grain. Similarly, there are water-efficient types with high carbon dioxide fixation and low leaf area that could be outstanding new crops for semiarid conditions. Long-glume types with high seed weight are especially promising for increasing seed size. All of these, and more, are genetic raw materials that could transform this crop.

The grain is already nutritious, but it might be improved even more. As noted, types containing up to 14 percent protein are known. Also, it is a high-methionine protein and, of all the essential amino acids, is the most difficult to find in grain-based foods. Thus these finger millets could be a "super cereal" in nutritional terms.

White-seeded forms that make good unleavened bread and bakery products are also known, and they too are undeveloped. Today's crop in Africa is overwhelmingly the coarse, rusty-red form that is mainly useful for porridge and brewing beer.

Hybrids between Indian and African varieties seem promising as well. These high-yielding "Indaf" types are popular in India. Similar hybridization and selection for improved Indaf varieties for African conditions is now being started. Hybridization, however, is difficult and mutation breeding is another approach worth exploring.

Some of finger millet's relatives have interesting traits that might be transferable. Among wild Eleusine species are perennials that might lend some of their enduring characteristics to finger millet. Others have genes for tolerance of heat, cold, drought, and waterlogging, as well as resistance to salinity and an ability to mobilize phosphorus and utilize nitrogen efficiently.

Less dramatic but more immediately practical plant-breeding needs are the fine-tuning of today's varieties. The most important objectives are resistance to blast, helminthosporium (another fungus), striga (parasitic witchweed), lodging, stressful soil and moisture conditions, and grain that can be more easily dehulled and ground. Other objectives might include fast seedling growth to compete better with weeds, shade-tolerant types for relay and intercropping, and types with anthocyanin pigmentation in the leaves (possibly obtainable through induced mutation), which could be spotted easily in the fields and would make weeding a much easier task.

#### **Post production research**

Reducing the labor to dehull and to grind grain is obviously a vital need. Less urgent needs include: (1) improvement of malting quality (important both for brewing and for making high-methionine weaning foods); and (2) new methods of processing, such as parboiling, milling, and puffing.

#### **D.10 Processing finger millet**

##### **Milling**

Mechanical milling is of course well known; for wheat, rice, and maize, it is a major industry. But for finger millet, this primary step in the commercial processing of a food grain is essentially unknown. Machinery for rubbing the bran (embryo) off finger millet has never been available, perhaps through a lack of interest but mainly because the grain is exceptionally difficult to mill by machine. Finger millet, therefore, is usually eaten as a whole-grain flour, and the presence of oil in the embryo means that its shelf life is short and its commercial use limited.

Finger millet seed is a challenge to mill because it is very small and because its seed coat is bound tightly to the edible part (endosperm) inside. Moreover, the grain is so soft and friable that conventional milling equipment cannot remove the outside without crushing the inside. However, farmers have long known that moistening finger millet (for about 30 minutes) toughens the bran and reduces its grip enough that it can be mechanically separated without crushing the rest.

A machine for doing this has now been developed in India. This so-called "mini millet mill" consists of a water mixer, a plate grinder, and various sifter attachments. It is a versatile device in which debranning and sizing the endosperm (into either flour or semolina) take place in a single operation. It yields fairly white products. It can also be used to process wheat, maize, sorghum, and pearl millet and will even remove the outer husk from finger millet seeds if the clearance between the grinder plates is reduced.

This machine, and others like it, could initiate a new era for finger millet as a processed grain of commerce. The flour would then have a good shelf life and could be trucked to the cities and sold in

stores as are wheat, rice, and maize. Commercial horizons would open up that have never before been contemplated.

### Malting

Finger millet could be the key to providing cheap and nutritious foods for solving, at last, the malnutrition that each year kills millions of babies throughout the warmer parts of the world.

The process of germinating finger millet activates enzymes that break down the complex structures of starches into sugars and other simple carbohydrates that are easy to digest. The enzymes are of course there to benefit the seeds in which they occur—to mobilize food for the growing seedling; but long ago people found that they could use them also to break up starches from other sources. This process (usually called malting) became the first step in making beer and liquor out of starchy foods such as potatoes, maize, rice, or sorghum.

What has been overlooked to a large extent is that malting can be used for more than just brewing. Indeed, it is probably the key to making cheap, digestible, liquid foods with little effort and no extra cooking fuel. These foods are particularly promising for children facing the life-threatening dietary switch from mother's milk to solid foods.

Adding a tiny amount of malted grain turns a bowl of hot starchy porridge into a watery liquid. The resulting food matches the viscosity of a bottled baby food, such as those sold in American supermarkets. A child who is too small or too weak to get down solids can then get a full meal—and get it out of the food its mother is preparing for the rest of the family.

The germinated grain acts as a catalyst to liquefy any of the world's major starchy foods: wheat, rice, maize, sorghum, millet, potatoes, cassava (manioc), yams, and the rest. Moreover, it does more than turn those staples into liquid form: it predigests the starches, making the food easy for a body to absorb, and (by releasing sugars) it renders even the blandest staples palatable. The malted grain is readily available, cheap, and safe to eat. It should develop healthy bodies and fully functioning brains in the millions of children whose health and happiness is now jeopardized by malnutrition.

Of all the world's cereal grains, finger millet is second only to barley in its ability to hydrolyze starches ("malting power"). And it has the inestimable value of growing in the latitudes where malnutrition is rife. (Barley is strictly a temperate-zone resource.)

But for all its potential to benefit the malnourished, not much attention has been paid to malting internationally. Only in India and Nepal have malt-based children's foods been intensively studied. In both countries, food scientists have created malted-grain products that can overcome malnutrition. And in almost every product, malted finger millet was the prime ingredient.

The fact that malting is a cheap and widely understood process that can be easily accomplished in the home or village and requires no fuel or special equipment is a major benefit. This means that top-quality weaning foods can be made by the poor, who cannot afford to buy commercial baby-food concoctions.

### D.11 Ragi

Finger millet crossed the Indian Ocean more than 1,000 years ago and since then has become extremely important in South Asia. In India, where it is generally called "ragi," this native African grain is now grown on more than 2 million hectares.

In its new home, scientists and farmers have created numerous ragi races. There are, for instance, plants that are purple; seedheads that are short, long, "open," "curved," or "fisty"; seeds that range from almost black to orange-red; and there is also a popular type whose seeds are pure white. Some ragi varieties are dwarfs (less than 50 cm), some tiller profusely, some are slow to mature and are grown mainly under irrigation, while others mature quickly and lend themselves to dryland production.

Ragi is considered one of India's best dryland crops, and most of it is produced without supplemental water. The plant is both adaptable and resilient: it survives on lateritic soils, it withstands some

salinity, and it has few serious diseases or pests. Ragi also yields well at elevations above those suitable for most other tropical cereals. In the Himalaya foothills, for example, it is cultivated up to slightly over 2,000 m above sea level.

Despite its importance in the Himalayas, about 75 percent of the ragi area lies in South India, particularly in Karnataka, Tamil Nadu, and Andhra Pradesh. In parts of this vast region farmers can get two crops a year; in Tamil Nadu and Andhra Pradesh three are not unknown. Wherever the rains at sowing time are uncertain, the farmers often transplant ragi like rice. In fact, the two crops are commonly grown in a "relay" that is good for both. For instance, in May a farmer may start out by sowing ragi seeds in the nursery; in June, he (or she) transplants the seedlings to the field and replants the nursery with rice seeds; in August, the ragi crop is harvested and the rice seedlings are put out into the just vacated fields. This process is efficient, highly productive, and a good insurance against the vagaries of the weather.

Ragi yields as much as 5,000 kg of grain per hectare. Because the seed can be stored for decades (some say 50 years), it is highly valued as a reserve against famines.

However, ragi is much more than just a famine food. In certain regions it is an everyday staple. It is, for instance, a principal cereal of the farming classes in Karnataka, Tamil Nadu, and Andhra Pradesh, as well as in the Himalaya hill tracts (including those of Nepal). The grain is mainly processed into flour, from which is made a variety of cakes, puddings, porridges, and other tasty foods. Some, however, is malted and turned into beer as well as into easily digested foods for infants and invalids.

As in its African homeland, ragi enjoys a reputation for being both nutritious and sustaining, and Indian studies lend scientific support to this view. Certain grain types, particularly the white ones, can match the most nutritious local cereals, at least in protein content.

## Annex E (informative)

### Finger millet — Codex, EU and USA pesticide residue limits

Users are advised that international regulations and permissible Maximum Residue Levels (MRL) frequently change. Although this International MRL Database is updated frequently, the information in it may not be completely up-to-date or error free. Additionally, commodity nomenclature and residue definitions vary between countries, and country policies regarding deferral to international standards are not always transparent. This database is intended to be an initial reference source only, and users must verify any information obtained from it with knowledgeable parties in the market of interest prior to the sale or shipment of any products. The developers of this database are not liable for any damages, in whole or in part, caused by or arising in any way from user's use of the database.

#### Results Key

MRL values in *{Italics}* are more restrictive than US

--- indicates no MRL value is established.

Cod, EU, etc. indicates the source of the MRL and EXP means the market defers to the exporting market.

All numeric values listed are in parts per million (ppm), unless otherwise noted

	US	Cod	EU 1
<b>2,4-D</b>	2	---	<i>{0.05}</i>
	1. European Union does not maintain a specific MRL for the 2,4-D/Millet, grain combination, but does maintain an MRL of 0.05 PPM for its "Cereals" group.		
	US 2	Cod	EU
<b>Acetochlor</b>	---	---	0.01
	2. MRL applies to indirect or inadvertent residues only. Does not apply to corn, sorghum, rice, or wheat, grain.		
	US	Cod	EU
<b>Benoxacor</b>	0.01	---	---
	US	Cod	EU
<b>Beta-cyfluthrin</b>	0.15	---	---
	US 3	Cod	EU 4
<b>Captan</b>	0.05	---	<i>{0.02}</i>
	3. United States does not maintain a specific MRL for the Captan/Millet, grain combination, but does maintain an MRL of 0.05 PPM for its "Grain, cereal, group 15" group.		
	4. European Union does not maintain a specific MRL for the Captan/Millet, grain combination, but does maintain an MRL of 0.02 PPM for its "Cereals" group.		
	US 5	Cod	EU
<b>Carbaryl</b>	1	---	<i>{0.5}</i>
	5. Proso millet		
	US 6	Cod	EU 7
<b>Carfentrazone-ethyl</b>	0.1	---	<i>{0.05}</i>
	6. United States does not maintain a specific MRL for the Carfentrazone-ethyl/Millet, grain combination, but does maintain an MRL of 0.1 PPM for its "Grain, cereal, group 15" group.		
	7. European Union does not maintain a specific MRL for the Carfentrazone-ethyl/Millet, grain combination, but does maintain an MRL of 0.05 PPM for its "Cereals" group.		
	US	Cod	EU
<b>Cyfluthrin</b>	0.15	---	<i>{0.02}</i>
	US	Cod 8	EU 9
<b>Deltamethrin</b>	1	2	2
	8. Codex does not maintain a specific MRL for the Deltamethrin/Millet, grain combination, but does maintain an MRL of 2 PPM for its "Cereal Grains" group.		
	9. European Union does not maintain a specific MRL for the Deltamethrin/Millet, grain combination, but does maintain an MRL of 2 PPM for its "Cereals" group.		

	US 10	Cod	EU
<b>Dicamba</b>	2	---	{0.3}
	10. Proso millet		
	US 11	Cod	EU
<b>EPTC</b>	0.1	---	{0.05}
	11. United States does not maintain a specific MRL for the EPTC/Millet, grain combination, but does maintain an MRL of 0.1 PPM for its "Grain Crops" group.		
	US 12	Cod 13	EU
<b>Fludioxonil</b>	0.02	0.05	0.05
	12. United States does not maintain a specific MRL for the Fludioxonil/Millet, grain combination, but does maintain an MRL of 0.02 PPM for its "Grain, cereal, group 15" group.		
	13. Codex does not maintain a specific MRL for the Fludioxonil/Millet, grain combination, but does maintain an MRL of 0.05 PPM for its "Cereal Grains" group.		
	US	Cod	EU 14
<b>Fluoride</b>	40	---	{2}
	14. European Union does not maintain a specific MRL for the Fluoride/Millet, grain combination, but does maintain an MRL of 2 PPM for its "Cereals" group.		
	US	Cod	EU
<b>Fluroxypyr</b>	0.5	---	{0.05}
	US 15	Cod 16	EU
<b>Glyphosate</b>	30	30	{0.1}
	15. United States does not maintain a specific MRL for the Glyphosate/Millet, grain combination, but does maintain an MRL of 30 PPM for its "Grain, cereal, group 15" group.		
	16. Codex does not maintain a specific MRL for the Glyphosate/Millet, grain combination, but does maintain an MRL of 30 PPM for its "Cereal Grains" group.		
	US 17	Cod 18	EU
<b>Imidacloprid</b>	0.05	0.05	0.05
	17. Proso millet and pearl millet		
	18. Codex does not maintain a specific MRL for the Imidacloprid/Millet, grain combination, but does maintain an MRL of 0.05 PPM for its "Cereal Grains" group.		
	US 19	Cod	EU 20
<b>Ipconazole</b>	0.01	---	0.01
	19. United States does not maintain a specific MRL for the Ipconazole/Millet, grain combination, but does maintain an MRL of 0.01 PPM for its "Grain, cereal, group 15" group.		
	20. European Union does not maintain a specific MRL for the Ipconazole/Millet, grain combination, but does maintain an MRL of 0.01 PPM for its "Cereals" group.		
	US	Cod	EU 21
<b>Mesotrione</b>	0.01	---	0.05
	21. European Union does not maintain a specific MRL for the Mesotrione/Millet, grain combination, but does maintain an MRL of 0.05 PPM for its "Cereals" group.		
	US 22	Cod 23	EU 24
<b>Metalaxyl</b>	0.1	{0.05}	{0.05}
	22. United States does not maintain a specific MRL for the Metalaxyl/Millet, grain combination, but does maintain an MRL of 0.1 PPM for its "Grain Crops" group.		
	23. Codex does not maintain a specific MRL for the Metalaxyl/Millet, grain combination, but does maintain an MRL of 0.05 PPM for its "Cereal Grains" group.		
	24. European Union does not maintain a specific MRL for the Metalaxyl/Millet, grain combination, but does maintain an MRL of 0.05 PPM for its "Cereals" group.		
	US	Cod 25	EU 26
<b>Phosphine</b>	0.1	0.1	0.1
	25. Codex does not maintain a specific MRL for the Phosphine/Millet, grain combination, but does maintain an MRL of 0.1 PPM for its "Cereal Grains" group.		
	26. European Union does not maintain a specific MRL for the Phosphine/Millet, grain combination, but does maintain an MRL of 0.1 PPM for its "Cereals" group.		

	<b>US 27</b>	<b>Cod</b>	<b>EU 28</b>
<b>Pyriproxyfen</b>	1.1	---	{0.05}
	27. United States does not maintain a specific MRL for the Pyriproxyfen/Millet, grain combination, but does maintain an MRL of 1.1 PPM for its "Grain, cereal, group 15" group.		
	28. European Union does not maintain a specific MRL for the Pyriproxyfen/Millet, grain combination, but does maintain an MRL of 0.05 PPM for its "Cereals" group.		
	<b>US 29</b>	<b>Cod</b>	<b>EU 30</b>
<b>Spinetoram</b>	1	---	{0.05}
	29. Proso millet and pearl millet		
	30. European Union does not maintain a specific MRL for the Spinetoram/Millet, grain combination, but does maintain an MRL of 0.05 PPM for its "Cereals" group.		
	<b>US 31</b>	<b>Cod 32</b>	<b>EU 33</b>
<b>Spinosad</b>	1.5	{1}	{1}
	31. United States does not maintain a specific MRL for the Spinosad/Millet, grain combination, but does maintain an MRL of 1.5 PPM for its "Grain, cereal, group 15" group.		
	32. Codex does not maintain a specific MRL for the Spinosad/Millet, grain combination, but does maintain an MRL of 1 PPM for its "Cereal Grains" group.		
	33. European Union does not maintain a specific MRL for the Spinosad/Millet, grain combination, but does maintain an MRL of 1 PPM for its "Cereals" group.		
	<b>US</b>	<b>Cod</b>	<b>EU</b>
<b>Sulfentrazone</b>	0.1	---	---
	<b>US 34</b>	<b>Cod 35</b>	<b>EU 36</b>
<b>Sulfuryl fluoride</b>	0.1	{0.05}	{0.05}
	34. MRL applies to postharvest use only.		
	35. Codex does not maintain a specific MRL for the Sulfuryl fluoride/Millet, grain combination, but does maintain an MRL of 0.05 PPM for its "Cereal Grains" group.		
	36. European Union does not maintain a specific MRL for the Sulfuryl fluoride/Millet, grain combination, but does maintain an MRL of 0.05 PPM for its "Cereals" group.		

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