**MILLET IN WEST AFRICA COUNTRIES**

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4. **INTRODUCTION**

Beyond the production level, little is known about **what**, **where,** **how and by whom are** key commodities transformed and - more importantly - how much is being made available for food consumption and in what form. The idea is to survey agents in value chains for staples who are present at the farmgate at the time of harvest and are engaged in buying the crops for particular markets, e.g. retail, feed, food processing and alcohol, and how much of the staple is retained by the farmer for seed and storage. The survey can also be implemented in conjunction with other surveys, namely on production, to ensure low cost and sustainability.

The **scope of this research is to study selected staple food commodities in particular regions to develop guidelines for monitoring food security at country level**. The analysis is based on physical characteristics, ways of utilization and storage, and traditional vs industrial methods to transform raw commodities into processed food. This should provide us with more detailed information on nutritional characteristics of staple food in relevant regions and what should be targeted. In order to proceed in this research, information has been collected on major staple foods, and notes have been drafted on crops and their transformation process. Starting from the structure of FAO Commodity Trees[[1]](#footnote-1), research has been conducted on (i) crop characteristics, plant anatomy and nutritive factors, for which different nutrition sources have been compared (e.g. West African Food Composition Tables, United States Department of Agriculture Agricultural Research Service Database[[2]](#footnote-2), ESS Nutritive Factors list[[3]](#footnote-3), etc.); and (ii) processed product transformation: how these primary commodities are transformed into processed food, nutritional characteristics, local recipes, etc.

In order to identify the importance of the commodities in diets and in key countries, data on *food supply* (kcal/capita/day), *protein supply quantity* (g/capita/day) and *fat supply quantity* (g/capita/day) have been downloaded from the FAOSTAT for the following crops: cassava, millet, maize, oats, rice milled, rice paddy, sorghum, soybean and wheat. For each country, the commodity supply on total food supply has been calculated, and the average for the last three available years (2007-2009) has been considered to rank results and identify where single commodities have a higher impact on total food supply.

Based on that information, countries and commodities have been selected, and what came to light is that **millet** is one of the most important staple foods in Africa. Millets are in the family of cereals grown globally with differential importance across continents and within regions of the world. They form a diverse group of small grains cultivated in diverse and adverse environments, mostly in the dry, semi-arid to sub-humid drought-prone agro ecosystems. Worldwide, there are nine species of millets with total production of 28.38 million tons, out of which 11.36 million tons (40%) are produced in Africa from six species. Millet is particularly relevant in diet for population in Niger, Mali and Burkina Faso.



The *millet supply* in Niger is around the **42%** of the *total food supply* share (average 2007-2009), which means about half of the Nigerian population diet composition.

The *total* *millet production* in Niger for the same country amounts at 2,993,836 tonnes (average 2007-2009), around **25%** of total crop food production in Niger (Table 1).

**Table 1: Millet production and millet supply in Niger (FAOSTAT DATA)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Millet Supply, Niger (kcal/capita/day)** | | |  | **Total Food Supply, Niger  (kcal/capita/day)** | | |  |  |
| **2007** | **2008** | **2009** | **Millet average supply (2007-2009)** | **2007** | **2008** | **2009** | **Total food average supply (2007-2009)** | **Millet supply/ Total supply (2007-2009)** |
| 979 | 1,031 | 1,045 | **1,018.33** | 2,394 | 2,451 | 2,489 | **2,444.66** | **41.66%** |
| **Millet Production, Niger (Tonnes)** | | |  | **Total Food Production, Niger (Tonnes)** | | |  |  |
| **2007** | **2008** | **2009** | **Millet average production (2007-2009)** | **2007** | **2008** | **2009** | **Total food average production (2007-2009)** | **Millet production/ Total production (2007-2009)** |
| 2,781,928 | 3,521,727 | 2,677,855 | **2,993,836.667** | 10,338,754 | 1,2956,898 | 9,483,493 | **10,926,381** | **27.40%** |

Total *millet supply* in Burkina Faso is around the **20%** of the *total food supply* share (average 2007-2009), which means about 1/5 of the Burkina Faso population diet composition.

Total *total* *millet production* in Burkina Faso for the same country amounts at 1,064,044 tonnes (average 2007-2009), around **12%** of total crop food production in Burkina Faso (Table 2).

**Table 2: Millet production and millet supply in Burkina Faso (FAOSTAT DATA)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Millet Supply, Burkina Faso (kcal/capita/day)** | | |  | **Total Food Supply, Burkina Faso  (kcal/capita/day)** | | |  |  |
| **2007** | **2008** | **2009** | **Millet average supply (2007-2009)** | **2007** | **2008** | **2009** | **Total food average supply (2007-2009)** | **Millet supply / Total supply (2007-2009)** |
| 559 | 559 | 451 | **523** | 2,618 | 2,617 | 2,647 | **2,627** | **19.91%** |
| **Millet Production, Burkina Faso (Tonnes)** | | |  | **Total Food Production, Burkina Faso (Tonnes)** | | |  |  |
| **2007** | **2008** | **2009** | **Millet average production (2007-2009)** | **2007** | **2008** | **2009** | **Total food average production (2007-2009)** | **Millet production/ Total production (2007-2009)** |
| 966,016 | 1,255,189 | 970,927 | **1,064,044** | 7,368,314 | 10,435,888 | 8,736,652 | **8,846,951** | **12.03%** |

Total *millet supply* in Mali is around the **20%** of the *total food supply* share (average 2007-2009), which means about 1/5 of the Mali population diet composition.

Total *total* *millet production* in Burkina Faso for the same country amounts at 1,326,475 tonnes (average 2007-2009), around **12%** of total crop food production in Mali (Table 3).

**Table 3: Millet production and millet supply in Mali (FAOSTAT DATA)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Millet Supply, Mali (kcal/capita/day)** | | |  | **Total Food Supply, Mali  (kcal/capita/day)** | | |  |  |
| **2007** | **2008** | **2009** | **Millet average supply (2007-2009)** | **2007** | **2008** | **2009** | **Total food average supply (2007-2009)** | **Millet supply / Total supply (2007-2009)** |
| 490 | 502 | 520 | **504** | 2,493 | 2,573 | 2,624 | **2,564** | **19.66%** |
| **Millet Production, Mali (Tonnes)** | | |  | **Total Food Production, Mali (Tonnes)** | | |  |  |
| **2007** | **2008** | **2009** | **Millet average production (2007-2009)** | **2007** | **2008** | **2009** | **Total food average production (2007-2009)** | **Millet production/ Total production (2007-2009)** |
| 1,175,107 | 1,413,908 | 1,390,410 | **1,326,475** | 9,016,135 | 10,065,794 | 13,169,066 | **10,750,332** | **12.34%** |

1. **COMMODITY CHARACTERISTICS[[4]](#footnote-4)**

Millet is nutritious, containing proteins, minerals, vitamins and micronutrients. Pearl millet is 9% to 13% protein, but there are large variations, from 6% to 21%. It also provides more energy than wheat, as the oil content, at 4.2%, is higher. Pearl millet is rich in B vitamins, potassium, phosphorus, magnesium, iron, zinc, copper and manganese.

**2.1 MILLET PHISICAL DESCRIPTION**

**Pearl millet**

Pearl millet, *Pennisetum glaucum*, is also known as spiked millet, bajra (in India) and bulrush millet (Purseglove, 1972). Pearl millet may be considered as a single species but **it includes a number of cultivated races**. It almost certainly **originated in tropical western Africa**, where the greatest number of both wild and cultivated forms occurs. About 2000 years ago the crop was carried to eastern and central Africa and to India, where because of its excellent tolerance to drought it became established in the drier environments.

The height of the pearl millet plant may range from 0.5 to 4 m and the grain can be nearly white, pale yellow, brown, grey, slate blue or purple. The ovoid grains are about 3 to 4 mm long, much larger than those of other millets, and the 1000-seed weight ranges from 2.5 to 14 g with a mean of 8 g. The size of the pearl millet kernel is about one-third that of sorghum. The relative proportion of germ to endosperm is higher than in sorghum.

**Minor millets**

Minor millets (also referred to as small millets) (Seetharam, Riley and Harinarayana, 1989) have received far less attention than sorghum in terms of cultivation and utilization. They include finger millet (*Eleusine coracana*), foxtail millet (*Setaria italica*), kodo millet (*Paspalum scrobiculatum*), common or prove millet (*Panicum miliaceum*), little millet (*Panicum sumatrense*) and barnyard or sawa millet (*Echinochloa crus-galli* and *Echinochloa corona*).

|  |  |  |
| --- | --- | --- |
| **CROP** | **COMMON NAMES** | **SUGGESTED ORIGIN** |
| ***Pennisetum glaucum*** | **Pearl millet, cumbu, spiked millet, bajra, bulrush millet, candle millet, dark millet** | **Tropical West Africa** |
| ***Eleusine coracana*** | **Finger millet, African millet, koracan, ragi, wimbi, bulo, telebun** | **Uganda or neighbouring region** |
| *Setaria italica* | Foxtail millet, Italian millet, German millet, Hungarian millet, Siberian millet | Eastern Asia (China) |
| *Panicum miliaceum* | Proso millet, common millet, hog millet, broom-corn millet, Russian millet, brown corn | Central and eastern Asia |
| *Panicum sumatrense* | Little millet | Southeast Asia |
| *Echinochloa crus-galli* | Barnyard millet, sawa millet, Japanese barnyard millet | Japan |
| *Paspalum scrobiculatum* | Kodo millet | India |

More information is available on finger millet than on any of the others. **Minor millets account for less than one percent of the foodgrains produced in the world today**. Thus they are not important in terms of world food production, but they are essential as food crops in their respective agro-ecosystems. They are mostly grown in marginal areas or under agricultural conditions where major cereals fail to give sustainable yields. Detailed descriptions of these millets are given by Purseglove ( 1972).

**Finger millet**

Finger millet, *Eleusine coracana L*., is also known as African millet, koracan, ragi (India), wimbi (Swahili), bulo (Uganda) and telebun (the Sudan). It is **an important staple food in parts of eastern and central Africa and India**. It is the principal cereal grain in northern and parts of western Uganda and northeastern Zambia. The **grains are malted for making beer**. Finger **millet can be stored for long periods** without insect damage (Purseglove, 1972) and thus it can be **important during famine**. Numerous cultivars have been identified. In India and Africa, two groups are recognized: African highland types with grains enclosed within the florets; and Afro-Asiatic types with mature grains exposed outside the florets. It is believed that Uganda or a neighbouring region is the centre of origin of E. coracana, and it was introduced to India at a very early date, probably over 3000 years ago. Though finger millet is reported to have reached Europe at about the commencement of the Christian era, its utilization is restricted mostly to eastern Africa and India.

The height of cultivars varies from 40 cm to I m and the spike length ranges from 3 to 13 cm. The colour of grains may vary from white through orange-red deep brown and purple, to almost black. The grains are smaller than those of pearl millet, and the mean 1000-seed weight is about 2.6 g.

**Foxtail millet**

Foxtail millet, *Setaria italica L*., is also known as Italian, German Hungarian or Siberian millet. It is generally considered to have been domesticated in **eastern Asia**, where it has been cultivated since ancient times. The main production area is China, but *S. italica* is the **most important millet in Japan and is widely cultivated in India** (Purseglove, 1972). It is believed to have been one of the five sacred plants of ancient China (from 2700 BC). Because of its short duration it is a suitable crop for growing by nomads, and it was probably brought to Europe in this way during the Stone Age, as seeds abound in the Lake Dwellings in Europe.

The height of the plants varies from 1 to 1.5 m and the colour of the grain varies from pale yellow, through orange, red and brown to black. The 1000-seed weight is about 2 g.

**Common millet**

Common millet, *Panicum miliaceum L*., is also known as prove millet, hog millet, broom-corn millet, Russian millet and brown corn. This millet is of ancient cultivation. It is the milium of the Romans and the true millet of history. It was cultivated by the early Lake Dwellers in Europe. It is believed to have been domesticated in central and eastern Asia and because of its ability to mature quickly was often grown by nomads.

The shallow-rooted plant varies in height between 30 and 100 cm. The grain contains a comparatively high percentage of indigestible fibre because the seeds are enclosed in the hulls and are difficult to remove by conventional milling processes. The 1000-seed weight is about 5 g (varying between 4.7 and 7.2 g). Common millet is particularly suited to dry continental conditions and grows in more temperate climates than other millets.

**Little millet**

Little millet, *Panicum sumatrense Roth ex Roemer & Schultes*, is grown throughout India to a limited extent up to altitudes of 2 100 m but is of little importance elsewhere. It has received comparatively little attention from plant breeders. The plant varies in height between 30 and 90 cm and its oblong panicle varies in length between 14 and 40 cm. The seeds of little millet are smaller than those of common millet.

**Barnyard millet**

Barnyard, Japanese barnyard or sawa millet [*Echinochloa crus-galli (L.) P.B.* and *Echinochloa colona (L.)*] is the fastest growing of all millets and produces a crop in six weeks. It is grown in India, Japan and China as a substitute for rice when the paddy fails. It is grown as a forage crop in the United States and can produce as many as eight harvests per year. The plant has attracted some attention as a fodder in the United States and Japan. The height of the plant varies between 50 and 100 cm.

**Kodo millet**

Kodo millet, *Paspalum scrobiculatum L*., is a minor grain crop in India but is of great importance in the Deccan Plateau. Its cultivation in India is generally confined to Gujarat, Karnataka and parts of Tamil Nadu. It is classified into the groups Haria, Choudharia, Kodra and Haria-Choudharia depending on panicle characters. Kodo is an annual tufted grass that grows to 90 cm high. Some forms have been reported to be poisonous to humans and animals, possibly because of a fungus infecting the grain. The grain is enclosed in hard, corneous, persistent husks that are difficult to remove. The grain may vary in colour from light red to dark grey.

**Grains and their structure**

**Kernels of millets show considerable diversity in colour, shape, size and certain anatomical components**.

The basic kernel structure is different millets. The **principal anatomical components** are **pericarp**, **germ** **or embryo** and **endosperm**. In finger, prove and foxtail millets the pericarp is like a sack, loosely attached to the endosperm at only one point. In these utricle-type kernels the pericarp easily breaks away, leaving the seed-coat or testa to protect the inner endosperm. The kernels of pearl millet are of the caryopsis type, in which the pericarp is completely fused to the endosperm.

The relative distribution of the three main kernel components varies. In pearl millet, it is pericarp 8.4 percent, endosperm 75 percent and germ 16.5 percent (Abdelrahman, Hoseney and Varriano-Marston, 1984). The ratio of endosperm to germ in pearl millet is 4.5:1. In finger and prove millets the germ is very small and therefore the endosperm-togerm ratio, 11:1 to 12:1, is much higher than in sorghum.

**Pericarp**

Pericarp is the outermost structural component of the caryopsis and is **composed of three sublayers**, namely **epicarp**, **mesocarp** and **endocarp**. The **epicarp** is further **divided into epidermis and hypodermic**.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Grain** | **Type** | **Shape** | **Colour** | | **1000-kenel weight (g)** | | |  | |  |  |
| Pearl millet | Caryopsis | Ovoid, hexagonal, globose | Grey, white, yellow, brown, purple | | 2.5-14 | | |  | |  |  |
| Finger millet | Utricle | Globose | Yellow, white, red, brown, violet | | 2.6 | | |  | |  |  |
| Proso millet | Utricle |  |  | | 4.7-7.2 | | |  | |  |  |
| Foxtail millet | Utricle |  |  | | 1.86 | | |  | |  |  |
|  |  |  |  |  | | |  | | |  |  |
|  | **Seed - coat** | | | **Alcurone** | | | | | |  |  |
| **Grain** | **Number of layers** | **Pigmented** | **Thickness (pm)** | **Number of layers** | | **Cell size (pm)** | | | |  |  |
| Pearl millet | 1 | Sometimes | 0.4 | 1 | | 16-30 x 5-15 | | | |  |  |
| Finger millet | 5 | Yes | 10.8-24.2 | 1 | | 18 x 7.6 | | | |  |  |
| Proso millet | 1 | No | 0.2-0.4 | 1 | | 12 x 6 | | | |  |  |
| Foxtail millet | 1 |  |  | 1 | |  | | | |  |  |
|  |  |  |  |  | |  | | | |  |  |
|  | **Starch granules** | | | | | **Protein bodies** | | | | | |
| **Grain** | **Diameter (µm)** | **Peripheral zone (µm)** | **Corneous zone (µm)** | **Floury zone (µm)** | | **Type** | | | **Size (µm)** | | **Location** |
| Pearl millet | 10-12 | 6.4 | 6.4 | 7.6 | | Simple | | | 0.6-0.7 | | All areas |
| Finger millet | 3-21 | 8-16.5 | 3-19 | 12-21 | | Simple/ compound | | | 2 | | Peripheral/ corneous |
| Proso millet | 2-10 | 3.9 | 4.1 | 4.1 | | Simple | | | 0.5-1.7 | | Peripheral |
| Foxtail millet | 10 |  |  |  | |  | | |  | |  |
|  |  |  |  |  | |  | | |  | |  |
| **Grain** | **Germ** | |  |  | |  | | |  | |  |
|  | **Size (µm)** | **Endosperm:germ** |  |  | |  | | |  | |  |
| ratio |  |  |  |  | |  | | |  | |  |
| Peart millet | 1420 x 620 | 4.5:1 |  |  | |  | | |  | |  |
| Finger millet | 980 x 270 | 11:1 |  |  | |  | | |  | |  |
| Proso millet | 1100 x 310 | 12:1 |  |  | |  | | |  | |  |
| Foxtail millet |  | 12:1 |  |  | |  | | |  | |  |

The **pericarp of the pearl millet caryopsis consists of an epicarp with one or two cell layers**, a **mesocarp** that varies in thickness because of genetic factors and an endocarp made up of cross and tube cells. During decortication or milling, the pericarp of pearl millet breaks at the cross and tube cell layers and fragments of endocarp may remain with the endosperm.

**Seed-coat or testa**

**Just underneath the endocarp is the testa layer or seed-coat**. The millet seed coat is a rich source of dietary fibre and phenolic compounds[[5]](#footnote-5). The thickness of the testa layer is not uniform. It is thick near the crown area of the kernel and thin near the embryo portion. In some genotypes there is a partial testa, while in others it is not apparent or is absent. In pearl millet the testa layer is thin and sometimes pigmented. In other millets the testa is always pigmented and is only a single layer thick. **In finger millet the testa is very thick, with five cell layers, and is also pigmented.**

**Endosperm**

The **largest component of the cereal kernel is the endosperm**, which is a major storage tissue. It is composed of an aleurone layer and peripheral corneous and floury zones. In all the millets, the aleurone layer is a single layer of cells which lies just below the seed-coat or testa. The **aleurone cells are rich in minerals, B-complex vitamins and oil and contain some hydrolysing enzymes**.

The peripheral endosperm is distinguished by long rectangular cells which are densely packed and contain starch granules and protein bodies enmeshed in the protein matrix. The starch in these cells is therefore not easily available for enzyme digestion, unless the protein associated with it is also reduced (Chandrashekar and Kirleis, 1988). The matrix protein in general is alkalisoluble glutelin and the protein bodies are alcohol-soluble prolamins which account for the largest proportion of total protein in the kernel.

The protein bodies in the endosperm of millets are spherical and differ in size among species and also within the endosperm of a single kernel. **In pearl millet the protein bodies are more numerous in the floury than in the corneous zone.**

The starch granules of corneous endosperm are polyhedral and differ in size in different millet species. In floury endosperm the starch granules are spherical and bigger than the starch granules of the corneous zone. The starch in the floury zone is more amenable to enzyme digestion. In pearl and finger millets, the starch granules of the floury endosperm are spherical and big.

The proportions of corneous and floury endosperm determine the texture of the millet kernel. In soft-textured kernels there is more floury than corneous endosperm. In hard-textured kernels, on the other hand, there is more densely packed corneous endosperm than floury endosperm. Foxtail millet contains very little floury endosperm and is of a hard, corneous texture. Finger and prove millet kernels, with the endosperm evenly divided between the corneous and floury zones, are of intermediate texture. In pearl millet the kernel texture varies widely, from all floury, very soft endosperm to all corneous, very hard or vitreous endosperm.

**Germ**

The embryonic axis and the scutellum are the two major parts of the germ. The scutellum is a storage tissue rich in lipids, protein, enzymes and minerals. In pearl millet the ratio of germ to endosperm is larger than in sorghum and other millet kernels.

**2.2 MILLET PRODUCTION**

**HARVESTING AND PREPARATION**

(<http://forest.mtu.edu/pcforestry/resources/studentprojects/jon/Millet.html>)

Millet is taken from the field by removing the long grainy head from the rest of the stock. Before it can be used for food **it must be processed to remove the uneatable portion of the husk**. The millet is first threshed to remove the usable grain from the hard husk and break-up the grain into smaller more manageable pieces. Further separation is then done by manual pounding. Grain is normally pounded with a wooden pestle in a wooden or stone mortar.

It is common for the millet to first be moistened with about 10 percent water or soaked overnight to make the pounding easier.

A woman working hard can at best pound only 1.5 kg of grain per hour. After the usable portion of the grain has been separated by pounding the edible portion is removed winnowing or sieving. Winnowing is a process to separate grains from chaff by blowing air. The whole content is thrown up in the air, and the grain and chaff get separated out by gravity. The lighter chafe is blow away leaving behind the heavier usable grain. The final step in processing millet is making flour. Traditional grinding stones used to grind grain to flour usually consist of a small stone which is held in the hand and a larger flat stone which is placed on the ground. Grain is crushed by the backward and forward movement of the hand-held stone on the lower stone. The work is very laborious, and it is hard work for anyone to grind more than 2 kg of flour in an hour.

**MILLET POST HARVEST OPERATIONS**

(<http://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compendium_-_MILLET.pdf>)

Small-scale farmers produce almost all millets for household consumption and localized trade. Very limited quantities of millet are produced in the developed countries. Correspondingly, only small quantities of millet are recorded in the international trade (FAO and ICRISAT, 1996).

The **major African producers** are **Nigeria and Niger**, both in **West Africa**. Other major producers are Burkina Faso, Chad, Mali, and Senegal in West Africa, and Sudan and Uganda in East Africa (Spencer and Sivakumar, 1987; FAO and ICRISAT, 1996). Pearl millet is the major millet grown in Africa. Apart from Uganda, which grows mainly finger millet, all the major African producers listed in Table 7 produce mainly pearl millet. In all the major African millet producing countries, the crop is of considerable importance in the agricultural system, and accounts for over one third of the total cereal output. In relative terms, pearl millet is more important to the agricultural systems and economies of Africa than other regions of the world.

Besides the **official trade**, **a substantial unrecorded quantity of millet is traded within subregion in Africa, with grain moving from surplus to deficit areas**. In **West Africa** forexample, there is **movement of millet during good years from surplus producing areas along the southern boundary of the Sahara both southward to higher-rainfall but millet deficient areas and northward to supply nomadic populations** (FAO and ICRISAT,1996).

**Millet marketing channels in many developing countries are not well developed** for the following three reasons:

1. scattered and irregular supplies;
2. large distances betweenproducing areas and the main urban centres; and
3. limited demand in urban areas (FAO and ICRISAT, 1996).

**International trade in millet is controlled by a few specialized trading companies** and generally conducted on a sample basis. Only Argentina is reported to have established official export quality standards (FAO and ICRISAT, 1996).

**Primary products**

Traditional methods are usually applied **to decorticate millet grains partially or completely before further processing and consumption**.

**Whole grains may as well be directly dry-milled** to give a range of products: **broken or cracked grains**, **grits**, **coarse meal** and **fine flour**. The **flour** thus obtained is **used in the preparation of an extensive variety of simple to complex food products**. They **can also be mixed with other flours** to form composite flours for soft and stiff porridges (Bangu et al., 2000).

**Secondary and derived products**

It is **unusual**, in any human society, for **cereals to be eaten as uncooked whole seeds** (Hulse et al., 1980). **For human food, the millet grains are customarily milled before being cooked**.

Dry milling embraces a **wide range of technologies** from **simple grinding** of the whole seed **between stones** or in a pestle and mortar to the **complex continuous system of precision rollers**.

Common millet (proso) contains a comparatively high percentage of indigestible fibre because the seeds are enclosed in the hulls, and difficult to remove by conventional milling processes (Matz, 1969 quoted by Hulse, et al., 1980).

**Crop Loss Assessment Techniques**

There are **several approaches** for estimating damage and yield losses in millets.

**One method, which has been successfully used in West Africa, involves the caging of individual panicles or whole plant stands into which a known number of insects are introduced** (Krall et al., 1995). Apart from **providing direct quantitative information on pest damage**, this method **can also be used to study pest activity**. However, **field trials and extensive surveys are necessary** to obtain data on the extent of crop damage and yield losses.

The **crop loss assessment techniques** can be classified as follows (Nwanze, 1988, quoted by Krall et al., 1995):

(a) *Incidence ratio*

(b) *Visual score paired analysis*

(c) *Damage density loss ratio*

(d) *Quantitative assessment (insecticide trials).*

Generally, **marketing systems have three main broad functions**[[6]](#footnote-6):

1. **logistical function**, including not only transformation of goods over time (storage), but al so embraces place (transportation), and form (**processing**) activities;
2. **informational function**;
3. **distributional function**.

Studying the agricultural markets is useful to know their structure, and to better understand the transformation process of commodities: that provide us with better information on the characteristics of processed products.

**2.3 MILLET UTILIZATION**

Of the 30 million tonnes of millet produced in the world about **90 percent is utilized in developing countries** and only a tiny volume is used in the developed countries outside the former Soviet Union. **Exact statistical data are unavailable for most countries**, but **it is estimated that a total of 20 million tonnes are consumed as food, the rest being equally divided between feed and other uses such as seed, the preparation of alcoholic beverages and waste**. **Six countries** (China, Ethiopia, India, the **Niger**, Nigeria and the former Soviet Union) are **estimated to account for about 80 percent of global millet utilization**.

**Estimated millet utilization, 1981/82 to 1985/86 average**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Region or country** | **Food (10³ t)** | **Feed (10³ t)** | **Other usesa (10³ t)** | **Total (10³ t)** | **Per caput food use (kg/yr)** |
| Africab | 7 094 | 122 | 1 921 | 9 137 | 13.5 |
| Burkina Faso | 381 | - | 60 | 441 | 50.8 |
| Ethiopia | 1 020 | - | 196 | 1 216 | 24.9 |
| Mali | 516 | 1 | 88 | 605 | 67.7 |
| Niger | 977 | 21 | 215 | 1 213 | 168.9 |
| Nigeria | 2 365 | 86 | 700 | 3 151 | 26.5 |
| Senegal | 397 | 2 | 80 | 479 | 64.4 |
| Uganda | 259 | 47 | 150 | 456 | 17.8 |
| Asia | 14441 | 1 665 | 1 305 | 17411 | 5.3 |
| China | 4 857 | 1 120 | 480 | 6 457 | 4.7 |
| India | 8794 | 150 | 710 | 9664 | 11.9 |
| Central America | - | - | - | - | - |
| South America | - | 91 | 5 | 96 | - |
| North America | - | 104 | 6 | 110 | - |
| Europe | - | 104 | 6 | 110 | - |
| USSR | 800 | 1 | 107 400 | 2 307 | 2.9 |
| Oceania | - | 13 | 2 | 15 | - |
| World | 22 335 | 3 144 | 3 642 | 29 121 | 4.8 |
| Developing countries | 21 535 | 1 878 | 3 231 | 26 644 | 6.1 |
| Developed countries | 800 | 1 266 | 411 | 2 477 | 0.7 |

**Notes:**

a Food seed, manufacturing purposes and waste.

b Including fonio, and teff.

*Source:* FAO,1990b.

**Human food**

**Per caput food consumption of millet** varies greatly among countries, though it **is highest in Africa**. In the Sahel, millet is estimated to account for about one-third of total cereal food consumption in Burkina Faso, Chad and the Gambia, roughly 40 percent in Mali and Senegal and over **twothirds in the Niger**. Other countries in Africa where millet is a significant food item include Ethiopia, Nigeria and Uganda. **Millet is also an important food item for the population living in the drier parts of many other countries, especially in eastern and central Africa but also in the northern coastal countries of western Africa**. In developing countries outside Africa, millet has local significance as a food in parts of some countries such as China, India, Myanmar and the Democratic People's Republic of Korea. Although national per caput levels are rather low in the countries that consume the most millet, i.e. China and India, food use of millet is important in certain areas of these countries.

World consumption of millet as food has only grown marginally during the recent past in contrast to the significant increase in consumption of other cereals. **There has been a tendency in all countries for the per caput consumption of millet to decline when per caput income exceeds certain levels because of the lower prestige associated with its consumption**.

**Animal feed**

**Utilization of millet as animal feed is negligible** in absolute terms and compared with other uses and other cereals. It has been estimated that only about 10 percent of the millet used globally is fed to animals.

**Regional trends in production and utilization of sorghum and millets**

**West Africa**

The **West African semi-arid tropics** are defined as those areas where rainfall exceeds potential evapotranspiration for two to seven months annually. This area encompasses all of Senegal, the Gambia, Burkina Faso and Cape Verde, major southern portions of Mauritania, Mali and the Niger and the northern portions of Cóte d'lvoire, Ghana, Togo, Benin and Nigeria. Cereals occupy nearly 70 percent of total cultivated area in this region and engage 50 to 80 percent of total farm-level resources (Matron, 1990). **Millets and sorghum account for 80 percent of cereal production**. During the last 25 years growth in millet production has been slow and the total output has been lower than the population growth per year. Average yield per unit area of millet has declined during this period, and the small production increases have primarily resulted from expansion of cropped area. **Many factors have contributed to the decreased productivity, including demographic pressure and ecological degradation**.

**2.4 MILLET STORAGE[[7]](#footnote-7)**

When **millet is stored** in developing countries, it is usually stored in small quantities in traditional containers, often on the farm. Large quantities are seldom accumulated and bulk storage is uncommon.

**Processing** involves the **partial separation and/or modification of the three major constituents of the cereal grain** - the **germ**, the **starch-containing endosperm** and the **protective pericarp**.

Various traditional methods of processing are still widely used, particularly in those parts of the semi-arid tropics where millets are grown primarily for human consumption. **Most traditional processing techniques are laborious, monotonous and carried out by hand**. They are almost entirely left for women to do. To some extent, the **methods that are used have been developed to make traditional foods to suit local tastes and are appropriate for these purposes**.

**Traditional techniques** that are commonly used include **decorticating** (usually by pounding followed by winnowing or sometimes sifting), **malting**, **fermentation**, **roasting**, **flaking** and **grinding**. These methods are **mostly labour intensive and give a poor-quality product**.

In general, **industrial methods of processing millets are not as well developed as the methods used for processing wheat and rice**, which in most places are held in much higher regard than millets. The potential for industrial processing of millets is good, and attempts to develop improved industrial techniques have been made in several countries. Custom milling has had a significant impact in several African countries where it has recently been introduced.

**Storage and loss risk**

The **objective of storage is to preserve as much as possible of the value of the grain for its intended future use**. This means either retaining as high a proportion of viable seeds as possible for planting at the next harvest or preserving as much as possible of the food value of the grain for as long as possible. Several factors lead to the loss of both viability and nutrients, but globally the main causes of loss are the depredations of pests (insects, birds and rodents) and mould damage. Germination of the grain (sprouting) also results in losses, but on a smaller scale. **Grain is stored by consumers and by processors for future consumption**. It is **also stored by commercial traders for resale**, **usually on the home market but occasionally for export**.

Moisture in the grain and the temperature of storage are the most important physical factors that contribute to losses (FAO, 1970b). Most activity that causes losses occurs more rapidly as the temperature increases. With even minor changes in temperature, moisture will migrate and accumulate in certain areas, either near the top of the container or in places that are cooler than the rest. This often allows microbiological activity to occur in comparatively dry grain. Microbiological activity usually produces heat, and in unventilated stores, moist areas can get so hot that charring can occur. At this stage the grain is ruined. It may even burst into flames when it is exposed to air.

Storage bins are best filled early in the day when the air is cool and the humidity is often at its lowest. The grain should be packed as tightly as possible to allow insects the minimum space to move around and to breed. Sand is sometimes mixed with the grain to reduce the free space further.

Studies conducted in **Senegal** showed that when properly dried and threshed millets were mixed with 30 percent sand, storage losses were reduced.

**Chemical composition of millets stored for different periods (moisture-free basis)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Storage period** | **Number of samples** | **Moisture (%)** | **Protein (g)** | **Non protein nitrogen (mg )** | **Thiamine (mg)** | **Riboflavin (mg)** | **Niacin (mg)** |
| **Pearl millet** |  | | | | | | |
| 1 month | 18 | 9.3 | 10 | 282 | 0 33 | 0.21 | 2.4 |
| 5months | 18 | 11 | 9.9 | 285 | 0.29 | 0.21 | 2.4 |
|  |  | (+18.3) | (-1.0) | (+1.1) | (-12 1) | 0 | 0 |
| 9months | 12 | 10.7 | 8.9 | 297 | 0.2 | 0.21 | 2 |
|  |  | (+15.1) | (-11.0) | (+5.3) | (-39.4) | 0 | (-16.7) |
| **Finger millet** |  | | | | | | |
| 1 month | 7 | 10.9 | 7.6 | 193 | 0.37 | 0.19 | 1.3 |
| 5months | 7 | 10.9 | 7.4 | 216 | 0.33 | 0.18 | 1.3 |
|  |  | 0 | (-2 6) | (+12.0) | (-10.8) | (-5.3) | 0 |
| 9months | 7 | 11.6 | 7.2 | 275 | 0.21 | 0.17 | 1.1 |
|  |  | (+6 4) | (-5.3) | (+42.5) | (-43.2) | (-10.5) | (-15.4) |

**Note**:

Figures in parenthese indicate percentage decrease (-) or incrrease (+) from the values at tile initial (one - month) sampling.

*Source*: Pushpamma et al., 1985.

**Methods used for storing grains are influenced by the value of the crop, the quantity stored and environmental conditions**. Compared to other cereal crops, millets are not widely traded internationally, and **within those developing countries where they are grown for human food there is usually a balance between local production and local demand**. **Farmers and rural householders in developing countries store most of what is grown in small storage structures.** There is not much need for bulk storage of these crops.

Storage containers vary from small traditional on-farm or domestic containers to silos which are sometimes found on large farms. In many countries, small granaries are made by weaving plant materials such as bamboo, stalks, bark and small branches and then sealing any gaps with mud or dung. These structures may be built directly on the ground or raised off the ground on platforms or stilts.

**Storage practices in Africa**

In some countries in **West Africa** **millet grains are mixed with wood ash and stored in clay pots** (Vogel and Graham, 1979). In Nigeria as unthreshed heads in a solid walled container called a rumbu. For short-term storage, bundles of millet heads are arranged in layers in the rumbu. For long-term storage of three to six years, the heads are laid out individually rather than in bundles. Some farmers spread the leaves of gwander daji (Anona senegalensis) on the bottom of the rumbu and between each layer of grain. When a rumbu is full, the mouth is sealed with clay.

**Storage of flour**

**Flour** is **usually produced as it is needed and is not often stored** for long periods because it tends to turn rancid. This is **particularly evident with pearl millet flour**, because of its very high tat content. Millets, particularly pearl millet, are therefore best stored as whole grain.

1. **COMMODITY PROCESSING METHODS**

**3.1 Traditional processing methods**

**Processing untreated grains**

**Flour made by grinding whole grain** is occasionally used, particularly with the smaller millets, but in most places where millets are consumed the **grain is partially separated into its constituents before food is prepared from it**.

The **first objective of processing is usually to remove some of the hull or bran** - the fibrous outer layers of the grain. This is **usually done by pounding followed by winnowing or sieving**. The grain may first be moistened with about 10 percent water or soaked overnight. When hard grains are pounded, the endosperm remains relatively intact and can be separated from the heavy grits by winnowing. With soft grains, the endosperm breaks into small particles and the pericarp can be separated by winnowing and screening.

When suitably prepared grain is pounded, the bran fraction contains most of the pericarp, along with some germ and endosperm. This traction is usually ted to domestic animals. **The other fraction, containing most of the endosperm and much of the germ along with some pericarp, is retained for human consumption**. Retaining the germ in the flour will improve aspects of its nutritional quality, but at the same time it will increase the rate at which the flour will become rancid. This is particularly important in the case of pearl millet.

**Dry, moistened or wet grain** is **normally pounded with a wooden pestle in a wooden or stone mortar**. Moistening the grain by adding about 10 percent water facilitates not only the removal of the fibrous bran, but also separation of the germ and the endosperm, if desired. Although this practice produces a slightly moist flour, many people temper the grain in this way before they pound it. Pounding moist or dry grain by hand is very laborious, time consuming and inefficient. A woman working hard with a pestle and mortar can at best only decorticate 1.5 kg per hour (Perter, 1983). Pounding gives a non-uniform product that has poor keeping qualities.

Many pearl millet grains have an irregular indentation in the pericarp. This makes it **more difficult to decorticate pearl millet** than it is to decorticate most other cereal grains (Kent, 1983).

The **particle size of the endosperm fraction can be reduced by crushing or grinding** **to produce coarse grits or fine flour**. This unpleasantly hard **work is almost always done by women**. Traditional grinding stones used to grind whole or decorticated grain to flour usually consist of a small stone which is held in the hand and a larger flat stone which is placed on the ground (Subramanian and Jambunathan, 1980; Vogel and Graham, 1979). Grain, which should be fairly dry, is crushed and pulverized by the backward and forward movement of the hand-held stone on the lower stone. The **crushing work is very laborious**, and it is **hard work for anyone to grind more than 2 kg of flour in an hour**. In a traditional process used in many countries of Africa, decorticated grain is crushed to a coarse flour either with a pestle and mortar or between stones. **Grain is also ground to coarse or fine flour in mechanized disk mills now located in many villages**.

In wet milling, the millet is soaked in water overnight (and sometimes longer) and then ground to a batter by hand, often between two stones. **Soaking makes the endosperm very soft and the pericarp quite tough and makes grinding much easier, but it gives a batter or paste instead of flour**.

1. **Processing malted grains**

Malting involves germinating grain and allowing it to sprout. Typically the grain is soaked for 16 to 24 hours, which allows it to absorb sufficient moisture for germination and for sprouts to appear.

**Alcoholic beverages and dumplings** are prepared in Kenya **from germinated millet**.

**In the germination process**, the grain produces a-amylase, an **enzyme that converts insoluble starch to soluble sugars**. This has the effect of thinning paste made by heating a slurry of starch in water, in turn allowing a higher caloric density in paste of a given viscosity, since as much as three times more flour can be used when the grain has been germinated. The **energy that young children can consume is often limited by the bulk that they can consume**. Thus **using germinated grain can make food more suitable for certain categories of young children**. **Flour from malted grain is consequently used quite widely in the production of children's food**.

Pal, Wagle and Sheorain (1976) measured the **changes in the constituents of various millets** (finger, pearl, prove, kodo and barnyard) **during malting**. The malting losses for finger millet and foxtail millet were high. Pearl millet had the highest a-amylase activity. Amylolytic and proteolytic enzyme levels in malted pearl millet were comparable to those in malted barley.

The use of only 5 percent malted finger millet was found to reduce the viscosity of weaning foods (Mosha and Svanberg, 1983; Seenappa, 1988).

**Processing parboiled grain**

Parboiling is reported to help in dehusking kodo millet (Shrestha, 1972) and to eliminate the stickiness in cooked finger millet porridge (Desikachar, 1975).

**3.2 Industrial processing methods**

While there are many machines available for processing hard white sorghum, there is unfortunately no well-proven industrial process available that is entirely satisfactory for making white products from coloured sorghums and millets.

**Cereal grains can be milled wet**, **in the form of a thin aqueous slurry**, usually **to produce starch**, **or** in an essentially **dry form** (often suitably dampened or "tempered") **which usually produces meal** (coarse or fine flour). **No millets have ever been wet milled commercially to produce starch**.

***The following technologies are all for dry and semi-wet milling.***

In **industrial processing**, once the **grain** has been **cleaned**, the first of step is the **separation of offal** (the portion not normally used for human consumption) **from the edible portion**. The **offal** consists of the **pericarp and sometimes the germ**. Offal removal is frequently called **decortication or dehulling**.

Following the removal of offal, the **edible portion is often milled to reduce the particle size of the edible fraction**. There is usually a **choice of techniques and mills that may be used** for particle size **reduction** if a finer product is **desired**. The technology for milling wheat is not optimal for milling sorghum and millet (Perter, 1977).

Most industrial operations that can be carried out on untreated grain can also be used with grain that hats been prepared in some way, for example grain that has been germinated and then suitably dried.

**Three types of processors can be used to mill millets** **on a commercial scale**: (i) **abrasive decorticators**, which abrade the pericarp away, i.e. progressively remove offal from the outside; (ii) **machines that rub** (rather than abrade) **the pericarp off the endosperm**; and (iii) **roller mills**, which cut the endosperm from the inside of the pericarp.

1. **Abrasive decortication**

Abrasive decorticators work by abrading away the fibrous pericarp. Obviously, the outer layers of the seed-coat are abraded away first and the innermost layers, which in many varieties contain those factors that most need to be removed, are the last to be abraded away. If all parts of all grains could be abraded away at the same rate, abrasive decortication would be an efficient way of removing the pericarp. However, different parts of individual grains are abraded away at very different rates, and there is some loss of endosperm (particularly from damaged grains) even when the grain is only lightly abraded. Also, non-spherical seeds, e.g. pearl millet grains, tend to abrade away much more quickly at some points than at others.

Most decorticators are based on a prototype put out by the Prairie Regional Laboratory (PRL) in Canada. This type of decorticator has the enormous advantages of being relatively inexpensive to install and relatively simple to maintain and operate. Bassey and Schmidt (1989) described the development of this type of decorticator and its use in Africa. More recently it has been introduced in India.

In 1976, a prototype decorticator was established in Maiduguri, Nigeria. A larger unit to process 5 to 10 tonnes of sorghum per day was installed at Pitsane in southern Botswana in 1978 but the demand for the product was inadequate to keep the equipment running at full capacity. The Centre national de recherches agronomiques (CNRA) in Bambey, Senegal, began to use a PRL decorticator to decorticate sorghum and millet in 1979. The capacity of this decorticator also exceeded the demand for the product.

FAO supplied the Food Research Centre (FRC) in the Sudan with a pilot plant including a decorticator manufactured in Germany after FRC had compared decorticators made by several different manufacturers. FRC is currently decorticating white sorghum for a local urban market. The centre has also produced pearled sorghum as a substitute for rice (Bad), Perten and Abert, 1980); although the product has to be cooked much longer than rice, it was well accepted. Of the five most popular varieties of sorghum grown in the Sudan, two (Feterita and Mayo) are unsuitable for abrasive decortication.

James and Nyambati (1987) described the industrial preparation of pearled brown and white sorghum in Kenya using a decorticator that could mill sorghum in batches or continuously, but they found it was difficult to obtain sufficient sorghum suitable for processing. The product was sold at 60 percent of the price of rice and consumer acceptance was very good. Flour was also produced from the pearled grain.

Various modifications have been made to the PRL design to suit specific conditions. A variant of the PRL decorticator was developed in the early 1980s by Palyi and tested in Canada. The Palyi-Hanson BR 001-2 can mill 3 tonnes per hour. Under local management in the Gambia a PRL decorticator processed 50 tonnes of pearl millet over a one-year test period, after which modifications were made to the design. In 1986 the Rural Industrial Innovation Centre (RIIC) introduced a modification that enabled the machine to handle small quantities of grain (Bassey and Schmidt, 1989). By 1989, about 35 RIIC decorticators had been installed in Botswana, but for one reason or another, not all of these machines are still being used for milling sorghum or millet. In turn, local agencies in some of the main countries to which the RIIC design has been exported (e.g. Zimbabwe, Senegal) have deemed it necessary to modify the RIIC design for improved operation for local grain.

In Zimbabwe, decorticators were placed in five rural locations for evaluation. A local research group, Environment Development Activities, produced a modified version that can process one tonne of grain in eight hours. In Senegal, a local modification was evaluated in ten villages. Decorticators based on a second local design (called the mini-SISMAR/ISRA), which can mill about 600 kg of grain in eight hours, were then introduced.

Equipment of RIIC design was introduced at Morogoro, United Republic of Tanzania, in 1982. Although the first unit was unsuccessful, four pilot systems were established locally for evaluation. In 1982, a mill with an RIIC decorticator was established in Ethiopia, but the supplies of grain for it were inadequate because of the drought.

There has also been an intensive effort to introduce RIIC decorticators in Andhra Pradesh. Decortication improved the quality of the flour from sorghum and millets so that it could be used in new ways (Geervani and Vimala, 1993).

High-yielding sorghums introduced in Mali were soft and could not be decorticated in PRL-type decorticators (Scheuring et al., 1983).

A number of large decorticators have been installed around the world with capacity ranging from 1 to 2.5 tonnes per hour. Typically, they are vertical axis units with abrasive disks that have been carefully selected for the optimal degree of abrasion. The grain is first cleaned to separate sand, dust, coarse material and other impurities. An aspirator removes the abraded bran through a screen. The bran is sometimes further separated into fine bran (mostly pericarp) and a mixture of germ, broken grain and coarse bran. A l-t/hour decorticator manufactured in Switzerland was run for several years in Zimbabwe, preparing coarse sorghum flour that was introduced into a wheat flour mill. A 2.5-l/hour unit manufactured in Germany was installed in the Sudan. Other large units are reportedly in operation in Nigeria. As with small units, high-quality sorghum is needed to produce an acceptably white product in these larger decorticators. Sufficient quantities of high-quality sorghum to keep large mills running at full capacity are not often available.

**Rubbing techniques**

Munck, Bach Knudsen and Axtell (1982) described a new industrial milling process developed in Denmark, which does not involve abrasive milling. Decortication is achieved by a steel rotor rotating the grain mass within a generally cylindrical chamber. When the grain is properly tempered, the pericarp is rubbed off by the movement of one seed against another. However, when the grain is too dry, as was the case in a factory in the Sudan, abrasion of the internal components of the mill becomes severe. The hulls and the endosperm fragments are separated in a cyclone and the endosperm particles are milled in a proprietary mill. These units have a capacity of 2 tonnes of sorghum per hour. The system was reported to yield 80 percent flour with whiteness comparable to traditional milling, but to do this it requires grain with specifications similar to those required for efficient abrasive decortication.

**Roller mills**

Most wheat is milled in a type of mill called a roller mill. Roller mills are the most efficient mills for separating the constituents of cereals. Two types of rollers are used: rollers with axial grooves, which cut the endosperm from the pericarp (effectively cutting it away from the inside), and smooth rollers, which progressively crush the endosperm pieces into finer and finer flour. Normally the grain is passed through a number of roller mills, often 20 or more. Wheat milling technology is suitable for milling large quantities of grain, but it requires a large investment and experience in operating and maintaining the equipment. For all these reasons, it is therefore not suitable for milling sorghum and millets in very small-scale operations. However, roller mills are very efficient in separating the edible portion of cereals from the offal and can do so with sorghum and millets regardless of the physical characteristics of the grain; it does not matter if the grain is soft, coloured or broken. Roller milling might therefore have a place where high-quality products are required from comparatively large quantities of grain of poor or indifferent quality, particularly where there is spare capacity in an existing wheat mill.

To withstand the stresses of roller milling, the pericarp of sorghum and millets has to be much moister than that of wheat. Early efforts to roller-mill sorghum and millets always ended in failure because the grain was dry when it was milled. It would shatter, the pericarp breaking into small pieces that were too brittle to allow separation of the endosperm. Using conventional tempering techniques, Perten (1983) was unable to achieve efficient separation of the offal of either sorghum or millets from the endosperm. He concluded that sorghum and millets are more difficult to grind than wheat and that they produce a coarser and much darker flour which contains high levels of fat and ash.

The use of moisture levels much higher than those used for milling wheat was first reported by Abdelrahman, Hoseney and Varriano-Marston ( 1983 ) for milling pearl millet and by Cecil (1986, 1992) for milling other millets and sorghum. The term semi-wet milling was adopted for this technique. For millets, about 10 percent water must be equilibrated in the grain for four hours before it is ready for milling; for sorghum, about 20 percent moisture must be added and the grain conditioned for six hours. The damp material flows almost as easily as normally tempered wheat products do, and no holdup problems were encountered in several hours of running 2 tonnes per hour of red sorghum in a commercial mill. In early experiments, comparatively low yields of fine flour were obtained, but subsequent work produced low-fibre, low-tannin grits from red sorghum in a commercial mill with six roller passes with a yield of 72 percent (compared with typical wheat recovery of 70 percent). In a laboratory mill with three milling passes, 84 percent yield of grits was obtained from commercial white sorghum from Botswana and 83 percent from white sorghum from Lesotho. All the grits contained very low levels of fibre.

Semi-wet milling has several advantages, including the excellent separation of the offal from the edible portion and the opportunity for using well-tested existing commercial wheat-milling equipment without the need for any changes in the set-up of the mills. White flour with practically no tannin, which tastes better, looks better and is nutritionally better than flour that contains tannin, can be produced from high-tannin coloured varieties. Mixtures of sorghum or millet varieties, soft varieties, misshapen seeds and mixtures of sorghum with other grains (including wheat) can all be milled together if necessary. Moistening the endosperm softens it to such an extent that very little energy is needed to mill it. Semi-wet milling of pearl millet, unlike abrasive decortication, may also help eliminate substances that cause goitre (Klopfenstein, Leipold and Cecil, 1991).

Redundant or underutilized wheat mills can be used with minimal additions and the mill can be reverted to milling wheat within a few minutes. Alternatively, any type of sorghum can be milled together with wheat. For a period of about five days, 0.6 tonnes of red sorghum and 14 tonnes of wheat per hour were milled together without difficulty in a commercial mill in Zimbabwe. Semi-wet milling has some disadvantages. Although it would not be difficult or very expensive in a commercial system to dry the products of semi-wet milling, they are usually too damp for long-term storage. In semi-wet milling, microbiological growth might be more vigorous than in conventional milling of wheat, but reasonable attention to hygiene will minimize this problem. Semi-wet milling is not suitable for very small operations. Finally, although it has been shown that sorghum can be milled semi-wet without any difficulty in commercial equipment, the technique has not yet been proved over an extended period of operation.

**Size reduction**

Many mills can be used to reduce the size of the particles obtained by decortication, but the type that is usually used (and is also probably the simplest to use and the cheapest to install) is the hammer mill. Hammer mills are available in all sizes. They consist of blunt blades rotating rapidly in an enclosed cylinder with an outlet covered by a screen. The size of the holes in the screen determines the size of the particles of flour, but small holes will reduce the throughput of the mill, and if they are too small overheating may result.

If roller mills are used for separating the endosperm from the offal, the particle size is usually reduced in roller mills with smooth rollers.

**FAOSTAT COMMODITY TREE: EXAMPLES OF MILLET PROCESSED FOOD**

**FLOUR OF MILLET**

(<http://www.cooksinfo.com/millet-flour>)

Flour made by grinding millet seed into a powder.

You can grind your own Millet Flour from millet seed in a blender or coffee mill. If you buy the seed already ground into flour, make sure the supply is fresh: it can go rancid quite quickly. The flour will have a creamy-white or pale yellow colour.

**Cooking Tips**

In yeast-risen breads, you can swap in from 1/2 to 3/4 cup of wheat flour for millet flour. In other baked goods that aren't risen with yeast, up to half the flour can be Millet Flour, though Millet Flour can make baked goods crumbly and dry if you use too much of it.

**Nutrition**

Gluten-free.

**Storage Hints**

Store in freezer. If it develops a slightly bitter aftertaste, discard it because it is starting to go off (it will be the protein and the oils in the flour going rancid).

**BRAN OF MILLET**

(<http://www.fao.org/docrep/t0818e/T0818E0a.htm>)

The pearl millet bran is low in mineral matter like that of sorghum, but it is remarkably rich in protein ( 17.1 percent). The germ fraction in pearl millet is relatively large, 16 percent as against 10 percent in sorghum. It is also rich in oil (32 percent), protein ( 19 percent) and ash ( 10.4 percent). Practically all the oil (87 percent) of the whole kernel is in the germ fraction, which also accounts for over 72 percent of the total mineral matter. Greater concentration of minerals in the germ and the bran layers than in endosperm is typical of cereal grains (MacMasters, Hinton and Bradbury, 1971). The total fat content of pearl millet is higher than that of other millets and sorghum because of the size of the germ and its high oil content and because of somewhat higher levels of fat in the bran fraction.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Kernel fraction** | **% of**  **kernel weight** | **Proteinb**  **(%)** | **Ash (%)** | **Oil**  **(%)** | **Starch**  **(%)** | **Calcium**  **(mg/kg)** | **Phosphorus**  **(mg/kg)** | **Niacin**  **(mg/100g)** | **Riboflavin**  **(mg/100g)** | **Pyridoxin**  **(mg/100g)** |
| **Pearl millet** |  | | | | | | |  |  |  |
| Whole kernel | 100 | 13.3 | 1.7 | 6.3 |  | 55 | 358 |  |  |  |
| Endosperm | 75 | 10.9 | 0.32 | 0.53 |  | 17 | 240 |  |  |  |
|  |  | (61) | (14) | (6) |  | (25) | (56) |  |  |  |
| Germ | 17 | 24.5 | 7.2 | 32.2 |  |  |  |  |  |  |
|  |  | (31) | (71) | (87) |  |  |  |  |  |  |
| Bran | 8 | 17.1 | 3.2 | 5.0 |  | 168 | 442 |  |  |  |
|  |  | (10) | (15) | (6) |  | (36) | (15) |  |  |  |

**Notes:**

a Values in parentheses represent percentage of whole kernel value.  
b N × 6.25   
Sources: Hubbard. Hall and Earle. 1950 (sorghum): Ahdelrahman. Hoseney and Varriano-Marston, 1984 (pearl millet).

**PROCESSING MILLET: MILLET MALT EXAMPLE**

**Production of quality millet malt for small-scale or semi-industrial food production in West Africa[[8]](#footnote-8)**

**Millet malting** is a widespread traditional practice in West Africa. It is used to produce **fermented and unfermented beverages** or is **incorporated into infant cereals**. The malting process has many benefits (nutrition, texturing) but the cottage-scale production conditions cause health risks inconsistent with market expectations. To improve malt production and properties, but also the maltsters’ income, a project to support specialised small and medium enterprises (SMEs) was carried out.

Cereal malt s one of the main raw materials used to prepare various traditional **alcoholic beverages** of West Africa: *dolo* (Mali, Burkina Faso), *tchoukoutou* and *chakpalo* (Benin, Togo, Niger, Côte d’Ivoire), *burukutu* or *pito* (Nigeria, Ghana), *dam* (Togo), but also **non-alcoholic beverages** like *gowé* (Benin). Malts are also incorporated into infant cereals to reduce their viscosity and increase their energy density.

To do so required taking **advantage of indigenous knowledge of the varieties** (sorghum and **millet**) **and traditional production practices**; evaluating the various markets’ quality and quantity requirements; developing and validating production methods suited to the scale of these undertakings; promoting and optimizing the production and marketing of malt and malt derivatives[[9]](#footnote-9).

The project was carried out in three stages:

1. **Surveys were done in the field to gather data on the socioeconomic production environment, crop varieties and traditional processing methods used.**
2. The malting process for *gowé* and *dolo* was optimised in the laboratory, then at the SMEs. Good manufacturing practices were developed and transferred to personnel through training.
3. The innovations were tested at the SMEs. Malt quality was assessed by measuring diastatic, microbiological and amylase activity. The fluidifying and nutritional properties of malt- based infant cereals were also measured.

**BEER OF MILLET**

Millet beer, also known as **Bantu beer**, **malwa**, **kaffir beer**, or **opaque beer**, is an **alcoholic beverage made from malted millet**. This type of beer is common throughout Africa. Related African drinks include maize beer and sorghum beer.

**Pito (beer)**

**Pito** is a type of **beer made from fermented millet** **in northern Ghana**, **parts of Nigeria**, and other parts of **West Africa**. It is made by small (household-level) producers, and is typically served in a calabash outside the producer's home where benches are sometimes provided.

**Pito** **can be served warm or cold**. **Warm** pito gets its heat from the fermentation process. Pito brewing can provide an important source of income for otherwise cash-poor households in rural areas. It is never found bottled or canned, and, as a rule, is purchased directly from the household in which it is brewed.

**METHODOLOGICAL APPROACH**

In order to analyze the life circle of millet products in Niger, a survey will be designed asking the producer and consumers for relevant information on production, consumption, utilization and market of millet.

As said above, millet is an important cereal crop for farmers in semi-arid areas in Western Africa.

It has been traditionally cultivated for home consumption, but in recent years market demand has increased. This offers new opportunities for smallholders to commercialize production, which is seen as a pathway for prosperity in the dry lands. Understanding production, consumption and utilization patterns for millet is important to study diet habits and food security of populations, and to develop strategies and awareness campaigns to promote and increase millet consumption: obtaining more information about utilization is one of the most important pre-condition for starting to consume it. Information about utilization is also the most important requirement to increase the consumption.

One strategy for the promotion of millet consumption is to point out the high nutritional value of this crop: millet crop would benefit from information campaigns about its nutritional value.

The survey is designed to interview consumers at three different market outlets to find out where consumers buy the cereal: supermarkets, small retail shops and open-air markets, in order to understand how the urbanization processes change the shopping behavior and highlights the importance of making millet available.

In addition, households are grouped into three different classes: low, middle and high income, to capture consumption habits of different income levels in rural and urban areas, for production and non-production zones.

To understand if millet is bought as grain and/or flour, it is important in order to comprehend the final utilization of the crop and its consumption.

It can also be useful to understand the reasons why some respondents may not consume millet (availability, price issues, etc.).

**SURVEY CONSTRUCTION AND INFORMATION NEEDED**

**EXAMPLE OF IMPACT ON COMMODITY EXTRACTION RATES**

Farmers = Sellers; Traders = Buyers; Households = Final consumer

QP = Quantity Produced

QS = Quantity Sold (Commercial Sale) = A1+B1+C1+…+N1 = 100% = Total quantity available to be processed

QP - QS > 0 = Stored, kind payments, seed, etc…

Total Quantity Processed = A2+B2+C2+…+N2 = 100% = Total quantity for final consumption

**Extraction Rates =**

**TO BE REVISED**

**PROCESSED PRODUCTS**

FEED

FLOUR

OTHER PROCESSED PRODUCTS\*…

WHOLE GRAINS

**N2%**

**A2%**

**A1%**

**QP**

**QS**

MILLET **PRODUCED**QUANTITY

**B2%**

FOOD INDUSTRY

NON-FOOD INDUSTRY

**B1%**

MILLET **SOLD** QUANTITY

**C2%**

**C1%**

BEER

**N1%**

OTHER BUYERS

\* e.g. Fermented beverages, infant food, etc.

**INFORMATION NEEDED FROM SELLERS, BUYERS AND CONSUMERS**

* Respondent details
* Millet physical characteristics + details
* Millet production and utilization + details
* Percentage of millet sold
* Main purpose of production of the holding + details
* Other economic production activities of the holding + details
* Use of good agricultural practices + details
* Use of organic agricultural practices + details
* Millet consumption (market) + details
* Land use land tenure + details
* Household food security + details
* …….

1. **PILOT DRAFT**

**Legend**:

Green cells: confirmed

Yellow cells: optional

The survey contains a list of information needed to update the extraction rates in staple food commodity trees.

It has to be better designed; information should be revised, adjusted and additional information might be needed.

The same survey can be used for all commodities in all countries, paying attention to local recipes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 1. **SECTION TO BE FILLED IN BY FARMERS**   **(millet sellers)** | | | |
|  | **Structural Indicators/Attributes** | **Key questions** | **Source of Data / Information** | **COMMENTS** |
|  | **Respondedt details:** |  |  | <http://oar.icrisat.org/7245/1/C_Schipmann_Schwarze_et_al_2013_ISEDPS_10.pdf> |
|  |  | Name/Title: |  |  |
|  |  | Age (years) |  |  |
|  |  | Male/Female |  |  |
|  |  | Complete address |  |  |
|  |  | Tel: |  |  |
|  |  | Email: |  |  |
|  | **MILLET PHYSICAL CHARACTERISTICS** | | | |
|  | Type of millet produced per typology: |  |  |  |
|  | *Pennisetum glaucum* L.*:* |  |  |  |
|  |  | Pearl millet |  | Only relevant crop for west agrica are listed  Tropical West Africa |
|  |  | Cumbu |  |
|  |  | Spiked millet |  |
|  |  | Bajra |  |
|  |  | Bulrush millet |  |
|  |  | Candle millet |  |
|  |  | Dark millet |  |
|  |  | Other, please specify |  |
|  | *Eleusine coracana* L.*:* |  |  |  |
|  |  | Finger millet |  | Only relevant crop for west agrica are listed  Uganda or neighbouring region |
|  |  | African millet |  |
|  |  | Koracan |  |
|  |  | Ragi |  |
|  |  | Wimb |  |
|  |  | Bulo |  |
|  |  | Telebun |  |
|  |  | Other, please specify |  |

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| --- | --- | --- | --- | --- |
|  | **Structural Indicators/Attributes** | **Key questions** | **Source of Data / Information** | **COMMENTS** |
|  | **MILLET PRODUCTION** | | | |
|  | **Primary millet production** |  |  |  |
|  |  | Area Harvested (Ha) | FAO Prod. Quest. |  |
|  |  | Production (MT) | FAO Prod. Quest. |  |
|  | **Producing millet mainly:** |  |  |  |
|  |  | For home consumption | WCA |  |
|  |  | For sale | WCA |  |
|  |  | Forms of in-kind payment | WCA |  |
|  | **Sold millet for:** |  |  | Utilization data refer to the use of crops in the country during the reference period.  On the utilization side a distinction is made between the quantitites used for food, seed, feed, liquid biofuels and industrial utilization. The general utilizations concept further include waste and imported/ exported quantities, which are not part of this survey.  Please provide the utilization in metric tonnes (MT) for the primary crops produced in your country. |
|  |  | Feed | FAO Prod. Quest. | Feed refers to quantities fed to animals, wether direct or used to produce compound feed. |
|  |  | Food industry | FAO Prod. Quest. | Food refers all quantities available for human consumption, either direct by the producers, available for human consumption at the retail level or processed for food use. |
|  |  | Non-food industry (Millet manufacturing) | WCA | Includes a whole range of activities associated with transforming raw materials into new products. For households, the most common manufacturing activities are f**ood processing**, making clothes and other textile materials, tanning, and making wood products. |
|  |  | Storage |  |  |
|  |  | Seed | FAO Prod. Quest. | Seed covers quantities used for reproductive purposes |

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|  | 1. **SECTION TO BE FILLED IN BY TRADERS**   **(millet buyers/industry)** | | | |
|  | **Structural Indicators/Attributes** | **Key questions** | **Source of Data / Information** | **COMMENTS** |
|  | **PROCESSING METHODS** |  |  |  |
|  | **Millet to be processed** |  |  |  |
|  |  | Total quantity of millet available to be processed |  |  |
|  | **Producer industry structure** |  |  |  |
|  |  | High tech production | MOA, NSO |  |
|  |  | Low tech production | MOA, NSO |  |
|  | **Traditional processing methods** |  |  |  |
|  |  | Quantity of millet processed by grinding whole grain |  |  |
|  |  | Quantity of millet processed into malted grains |  |  |
|  |  | Quantity of millet processed into parboiled grains |  |  |
|  | **Industrial processing methods** |  |  |  |
|  |  | Quantity of millet grains milled semi-wet |  |  |
|  |  | Quantity of millet grains milled wet |  |  |
|  | **Millets milled on a commercial scale** |  |  |  |
|  |  | Quantity of millet processed by abrasive decortication |  |  |
|  |  | Quantity of millet processed by rubbing techniques |  |  |
|  |  | Quantity of millet processed by roller mills |  |  |

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|  | **Structural Indicators/Attributes** | **Key questions** | **Source of Data / Information** | **COMMENTS** |
|  | **PROCESSED FOOD - MILLET TREE** | |  |  |
|  | **Selected derived millet commodities from FAO Millet Commodity Tree** |  |  |  |
|  | **Flour1** |  |  |  |
|  |  | Quantity of flour of millet produced |  |  |
|  | **Bran2** |  |  |  |
|  |  | Quantity of bran of millet produced |  |  |
|  | **Beverages** |  |  |  |
|  |  | Quantity of millet malted to produce fermented beverages |  |  |
|  |  | Quantity of millet malted to produce unfermented beverages |  |  |
|  |  | Quantity of beer of millet produced |  |  |
|  | **Infant food** |  |  |  |
|  |  | Quantity of millet malted to be incorporated into infant cereals |  |  |
|  | **Other processed products** | Any other processed products (please specify) |  |  |

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|  | 1. **SECTION TO BE FILLED IN BY HOUSEHOLDS** | | | |
|  | **Structural Indicators/Attributes** | **Key questions** | **Source of Data / Information** | **COMMENTS** |
|  | **MILLET CONSUMER MARKET** |  |  | <http://oar.icrisat.org/7245/1/C_Schipmann_Schwarze_et_al_2013_ISEDPS_10.pdf> |
|  | **Type of household consuming millet on a monthly basis** |  |  |  |
|  |  | Urban |  |  |
|  |  | Rural |  |  |
|  |  | Non-producer |  |  |
|  |  | Producer |  |  |
|  |  | Low income |  |  |
|  |  | Middle income |  |  |
|  |  | High income |  |  |
|  | **Monthly consumption of millet on a household level, quantity** |  |  |  |
|  |  | Bought as grain |  |  |
|  |  | Bought as pure flour |  |  |
|  |  | Bought as blended flour |  |  |
|  |  | Mean amount bought (kg) |  |  |
|  |  | Amount bought as grain (kg) |  |  |
|  |  | Amount bought as pure flour (kg) |  |  |
|  |  | Amount bought as blended flour |  |  |
|  | **Utilization of millet in by consumers** |  |  | A deeper research on regional recipe to be conducted |
|  |  | Porridge blended |  |  |
|  |  | Porridge pure |  |  |
|  |  | Ugali blended |  |  |
|  |  | Other, please specify |  |  |

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|  | **Structural Indicators/Attributes** | **Key questions** | **Source of Data / Information** | **COMMENTS** |
|  | **Future demand for millet and reasons for changing demand** |  |  |  |
|  | **Demand** |  |  |  |
|  |  | Increasing |  |  |
|  |  | Decreasing |  |  |
|  |  | Constant |  |  |
|  | **Reasons if increasing** |  |  |  |
|  |  | Family size |  |  |
|  |  | Availability |  |  |
|  |  | Taste |  |  |
|  |  | Cheap |  |  |
|  |  | Healthy |  |  |
|  |  | Own cultivation |  |  |
|  |  | Easy to blend |  |  |
|  |  | Habit |  |  |
|  |  | Learned utilization |  |  |
|  |  | Increased income |  |  |
|  | **Reasons if decreasing** |  |  |  |
|  |  | Family size |  |  |
|  |  | Expensive |  |  |
|  |  | Taste |  |  |
|  |  | Not available |  |  |
|  |  | Decreased income |  |  |
|  | **Reasons if constant** |  |  |  |
|  |  | Family size |  |  |
|  |  | Consume enough |  |  |
|  |  | Dificult to prepare |  |  |
|  |  | Taste |  |  |
|  |  | Expensive |  |  |
|  |  | Constant income |  |  |
|  |  | Not available |  |  |

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| --- | --- | --- | --- | --- |
|  | **Structural Indicators/Attributes** | **Key questions** | **Source of Data / Information** | **COMMENTS** |
|  | **Demand for millet flour of consumers who buy millet flour** |  |  |  |
|  | **Bought** |  |  |  |
|  |  | Loose |  |  |
|  |  | Packed |  |  |
|  | **Reasons if packed** |  |  |  |
|  |  | Quality |  |  |
|  |  | Convenience |  |  |
|  |  | Availability |  |  |
|  |  | Other, please specify |  |  |
|  | **Reasons if loose** |  |  |  |
|  |  | Quality |  |  |
|  |  | Price |  |  |
|  |  | Blend to own taste |  |  |
|  |  | Availability |  |  |
|  |  | Other, please specify |  |  |
|  | **Buying same brand if packed** |  |  |  |
|  |  | No |  |  |
|  |  | Yes |  |  |
|  | **Consumption experiences of millet of non-consumers** |  |  |  |
|  | **Millet** |  |  |  |
|  |  | No |  |  |
|  |  | Yes |  |  |
|  | **Frequency** |  |  |  |
|  |  | Few times |  |  |
|  |  | Regularly |  |  |
|  | **Utilization and Preparation knowing** |  |  |  |
|  | Regional recipes: please indicate any additional ingredient |  |  | *Additional ingredients:* |
|  |  | 1 |  |  |
|  |  | 2 |  |  |
|  |  | 3 |  |  |
|  |  | 4 |  |  |
|  |  | 5 |  |  |
|  |  | 6 |  |  |
|  |  | Etc… |  |  |
|  | **Structural Indicators/Attributes** | **Key questions** | **Source of Data / Information** | **COMMENTS** |
|  | **Awareness about the nutritional value of ~~finger~~ millet** |  |  |  |
|  | **Awareness of consumer** |  |  |  |
|  |  | No |  |  |
|  |  | Yes |  |  |
|  | **Awareness non-consumers** |  |  |  |
|  |  | No |  |  |
|  |  | Yes |  |  |
|  | **Knowledge consumers** |  |  |  |
|  |  | Provides energy |  |  |
|  |  | Is nutritious |  |  |
|  |  | Increases appetite |  |  |
|  |  | Has proteins |  |  |
|  |  | Strengthening |  |  |
|  |  | Good for diabetic |  |  |
|  |  | Good for blood |  |  |
|  |  | Good for children |  |  |
|  |  | Other, please specify |  |  |
|  | **Knowledge non-consumers** |  |  |  |
|  |  | Provides energy |  |  |
|  |  | Is nutritious |  |  |
|  |  | Increases appetite |  |  |
|  |  | Has proteins |  |  |
|  |  | Strengthening |  |  |
|  |  | Good for diabetic |  |  |
|  |  | Good for blood |  |  |
|  |  | Good for children |  |  |
|  |  | Other, please specify |  |  |

1. FAO commodity list is tailored on commodity trees so that the primary crop and its derived products are traceable all along the value chain of agricultural production. [↑](#footnote-ref-1)
2. <http://www.ars.usda.gov/main/site_main.htm?modecode=12-35-45-00> [↑](#footnote-ref-2)
3. <http://www.fao.org/economic/the-statistics-division-ess/publications-studies/publications/nutritive-factors/en/> [↑](#footnote-ref-3)
4. <http://www.fao.org/docrep/t0818e/T0818E01.htm#Pearl%20millet> [↑](#footnote-ref-4)
5. <http://www.ncbi.nlm.nih.gov/pubmed/20979682> [↑](#footnote-ref-5)
6. <http://www.fao.org/fileadmin/user_upload/sifsia/docs/Marketing%20Cost%20Margin%20Final%20May%202011%20%282%29.pdf> [↑](#footnote-ref-6)
7. <http://www.fao.org/docrep/t0818e/T0818E08.htm#Chapter%203%20-%20Storage%20and%20processing> [↑](#footnote-ref-7)
8. <http://www.agropolis.org/pdf/chapters_duras/sorghum_millet_west_africa.pdf>

   The project “*Production of quality sorghum or millet malts for small- scale or semi-industrial food production in West Africa*” sought to create the necessary conditions for small-scale production, but also marketing, of high-quality sorghum and millet malts for beverage and baby food undertakings. [↑](#footnote-ref-8)
9. Improved malt production methods were validated in the field at two pilot SMEs: ALITECH Industries in Benin and Unité de Maltage de Ouidtinga (UMAO) in Burkina Faso. [↑](#footnote-ref-9)