CEREALS.

The origin, economic importance, morphological description and agronomy of four most important cereals (Wheat (*Triticum aestivum L*), Rice (*Oryza sativa L.*), Maize (*Zea Mays L.*), and Sorghum *(Sorghum bicolor (L.) Moench)*) in the food security of Nigeria are discussed.

WHEAT (Triticum aestivum L.)

Family

Poaceae (Gramineae)

Origin

The Bread wheat originated from Armenia in Transcaucasia to the south-west coastal areas of the Caspian Sea in Iran. The Hybridization of a wild *Aegilops* species (*Aegilops tauschii* Coss., with the D-genome) with emmer, an old type of cultivated wheat belonging to *Triticum turgidum* L., gave rise to the hexaploid wheats i.e bread wheat (Triticum aestivum L.) and spelt wheat (*Triticum spelta* L.). The D-genome conferred on bread wheat and spelt wheat the adaptation to cold winters and humid summers thus allowing them to conquer temperate Europe and Asia.

ECONOMIC IMPORTANCE

According to FAO estimates, the average world production of wheat grain (bread wheat and durum wheat together) in 1999–2003 amounted to 576 million t/year from 209 million ha. Worldwide, bread wheat constitutes more than 90% of the area under the cultivated wheats. Wheat production in tropical Africa in 1999–2003 was 2.5 million t/year from 1.6 million ha, and in Nigeria (75,000 t/year from 53,000 ha. The main importer in tropical Africa is Nigeria (1.9 million t/year in 1998–2002),

CULTIVATED SPECIES

- Common wheat or Bread wheat (*T. aestivum*) – A hexaploid species that is the most widely cultivated in the world.

- Durum (*T. durum*) – The only tetraploid form of wheat widely used today, and the second most widely cultivated wheat.
- Einkorn (*T. monococcum*) – A diploid species with wild and cultivated variants.
- Emmer (*T. dicoccum*) – A tetraploid species, cultivated in ancient times but no longer in widespread use.
- Spelt (*T. spelta*) – Another hexaploid species cultivated in limited quantities.

CLASSES

- Durum – Very hard, translucent, light-colored grain used to make semolina flour for pasta .
- Hard Red Spring – Hard, brownish, high-protein wheat used for bread and hard baked goods.
- Hard Red Winter – Hard, brownish, mellow high-protein wheat used for bread, hard baked goods.
- Soft Red Winter – Soft, low-protein wheat used for cakes, pie crusts, biscuits, and muffins.
- Hard White – Hard, light-colored, opaque, chalky, medium-protein wheat planted in dry, temperate areas. Used for bread and brewing.
- Soft White – Soft, light-colored, very low protein wheat grown in temperate moist areas.

MORPHOLOGICAL DESCRIPTION

Annual, tufted grass up to 150 cm tall, with 2–5(–40) tillers. The stem (culm) cylindrical, smooth, hollow except at nodes. The leaves distichously alternate, simple and entire; leaf sheath rounded, auricled; ligule membranous; blade linear, 15–40 cm × 1–2 cm, parallel-veined, flat, glabrous or pubescent. The inflorescence is a terminal, distichous spike 4–18 cm long, with sessile spikelets borne solitary on zigzag rachis. The spikelet 10–15 mm long, laterally compressed, 3– 9-flowered, with bisexual florets, but 1–2 uppermost ones usually rudimentary. The fruit is an ellipsoid caryopsis (grain), at one side with a central groove, reddish brown to yellow or white.

ECOLOGY.

Bread wheat is most successful between 30–60°N and 27–40°S. The optimum temperatures for development are 10–24°C, with minima of 3–4°C and maxima of 30–32°C. Average temperature of about

18°C is optimal for yield. Temperatures above 35°C stop photosynthesis and growth, and at 40°C the heat kills the crop. In the tropics it is best grown at higher elevations (1200–3000 m) or in the cooler months of the year as Wheat does not grow well under very warm conditions with high relative humidity. At least 250 mm water required during the growing season for a good crop; it can be grown in areas that receive 250–750 mm rain annually. Wheat flower earlier at long daylengths, but do not require a particular daylength to induce flowering. The soils should be well aerated, well drained, and deep, with 0.5% or more organic matter. Optimum soil pH ranges between 5.5 and 7.5. Wheat is sensitive to soil salinity.

PROPAGATION AND PLANTING

Propagation is by seed. The 1000-seed weight is 30–50 g. Make use of seeds that has been treated with fungicides against soil- and seed-borne diseases. Wheat is sown by hand or machine. Seeds can be broadcast, drilled, or dibbled and incorporated in the soil using an animal-drawn plough or machine-drawn disc. The common seed rates are 150–200 kg/ha for broadcasting and 75–120 kg/ha for row-planting. The optimum spacing is 10–25 cm between rows, but it may extend up to 35 cm. The sowing depth is 2–5(–12) cm, with deeper planting required in dry conditions. At a sowing depth beyond 10–12 cm seedling emergence is poor. For rainfed wheat, the seed can be dry-sown, before the start of the rainy season, or when the soil is moist. Bread wheat is usually grown in sole cropping.

GROWTH AND DEVELOPMENT

Germination occurs at temperatures of 4–37°C, the optimum is 12–25°C. The radicle emerges first and the coleoptile emerges 4–6 days after germination. The first true leaf of the seedling emerges from the coleoptile. The primary roots may remain functional for life unless destroyed by disease or mechanical injury. Secondary roots start to develop about 2 wks after seedling emergence. They arise from the basal nodes and form the permanent root system, which spreads out and may penetrate as deep as 2 m, but normally not more than 1 m. Leaf and tiller production increase rapidly soon after crop emergence. The duration of the vegetative stage may vary from 20–150 days depending on temperature and the cultivar's vernalization and daylength response. For floral induction, spring types usually require temperatures between 7°C and 18°C for 5–15 days, while winter types require temperatures between 0°C and 7°C for

30–60 days. Flowering begins at the middle third of the spike and continues towards the basal and apical parts in 3–5 days. All spike-bearing tillers eventually flower almost simultaneously. Wheat is normally self-pollinated; cross-pollination is 1–4%. Pollen is largely shed within the floret. Stigmas remain receptive for 4–13 days. Pollen is viable for up to 30 minutes only. Grains in the centre of the spike and in the proximal florets tend to be larger than the other ones. Physiological maturity is reached when the flag leaf (uppermost leaf) and spikes turn yellow and the moisture content of the fully formed grain has dropped to 25–35%. The complete crop cycle of bread wheat varies from 50–200 days in tropical Africa.

MANAGEMENT

Uniform crop stand and early vigour discourage weed growth in bread wheat. Tillering allows the crop to compensate for poor stands and variable weather conditions. Yield losses due to weeds are caused by early competition in the first 4–5 weeks. Hand weeding, tillage practices, stubble management, pre-sowing irrigation, proper crop rotation and herbicides may control weeds. In Nigeria wheat production is restricted to the river basin irrigation schemes of the northern states. The mean nutrient removal per 1 t/ha of grain is 40–43 kg N, 5–8 kg P, 25–35 kg K, 2–4 kg S, 3–4 kg Ca, 3–3.5 kg Mg, and smaller amounts of micronutrients. The exact values depend on the available nutrients and water in the soil, the temperature, and the cultivar. Average fertilizer rates range from 9 kg N and 10 kg P on rainfed wheat to 180 kg N, 84 kg P and 50 kg K on irrigated wheat. Boron deficiency, resulting in grain set failure, can be observed on certain soils. Wheat is best rotated with non-grass crops, particularly with pulses. In some regions double cropping systems are common, with irrigated wheat grown in the cool dry season and crops such as cotton, sorghum, maize, soya bean and groundnut in the hot rainy season..

DISEASES

- Stripe rust or yellow rust (*Puccinia striiformis*), spread by air-borne uredospores.
- Septoria leaf blotch (*Septoria tritici*, synonym:*Mycosphaerella graminicola*).
- Stem rust or black rust (*Puccinia graminis*)

- Common bunt (*Tilletia* spp.),
- loose smut (*Ustilago tritici*, synonym:*Ustilago nuda* f.sp. *tritici*),
- Bacterial leaf streak or black chaff (*Xanthomonas translucens*).

PESTS

- Important insect pests are aphids, which may also transmit viruses.
- The African migratory locust (*Locusta migratoria*) is a periodic pest.
- The Hessian fly (*Mayetiola destructor)*
- Important storage insects, include *Sitophilus* spp. on whole grains
- *Tribolium* spp. and *Ephestia cautella* (synonym: *Cadra cautella*, flower moth) on wheat flour.
- Clean storage conditions and maintaining grain moisture and temperature at sufficiently low levels inhibit insect activity and development. Rodents, mainly the black rat (*Rattus rattus*), also damage stored seeds.

YIELD

The mean yield of wheat in tropical Africa is estimated at about 1.5 t/ha. Lower yields are due to high temperature, high humidity, disease pressure and the low levels of fertilizer applied. Maximum recorded grain yields of irrigated winter and spring wheats are 14 and 9.5 t/ha, respectively; the absolute maximum yield, based on genetic potential, is estimated at 20 t/ha.

HANDLING AND HARVEST

Threshed grain of bread wheat is winnowed, cleaned and prepared for store or market. Seeds should be dried to a moisture content of 13–14% for safe storage. High temperatures and moist conditions may result in spoilage. Regular re-drying may be necessary to maintain seed viability, if the seed is not stored in an airtight container.

NUTRITIONAL COMPOSITION

The composition of wheat grain is 7–8% coat material, 90% endosperm and 2–3% embryo. The embryo mainly comprises oil and protein, and little starch. The endosperm is starchy, and is surrounded by the aleurone layer which is rich in proteins. When a wheat grain is milled, the outer layers and embryo are separated from the endosperm. The pulverized endosperm becomes wheat flour, while the other parts form the bran. Hard bread wheat grain is best suited for bread making while the soft wheat grain is best for cookies, cakes and pastries. Flour colour varies from white to slightly yellow

USES

- Bread wheat flour is made into bread, pastries, crackers, biscuits, noodles, breakfast foods, baby foods and food thickeners. It is also used as a brewing ingredient in certain beverages (white beer). Industrial uses of wheat products centre on the production of glues, alcohol, oil and gluten. By-products of flour milling, particularly the bran, are used almost entirely to feed livestock, poultry or prawns. Wheat germ (from wheat embryos) is sold as a human food supplement. Straw is fed to ruminants or used for bedding material, thatching, wickerwork, newsprint, cardboard, packing material, fuel and as substrate for mushroom production. In many dry parts of the world it is chopped and mixed with clay to produce building material.

RICE (Oryza sativa L.)

Family

Poaceae (Gramineae)

ORIGIN

Oryza sativa evolved in Asia, but the exact time and place of its domestication are not known for certain. Remains of rice in China have been dated to 6500 BC; the earliest archaeological evidence from India goes back to 2500 BC. *Oryza sativa* was brought from Asia into tropical Africa along different routes. Most probably *Oryza sativa* migrated from Egypt, where it was introduced about 800–900 AD, to West Africa. The final penetration of *Oryza sativa* into Africa was along the slave trading routes from the East African coast and Zanzibar to DR Congo from about 1500 AD onwards. Nowadays it is cultivated throughout the humid tropics and in many subtropical and temperate areas with a frost-free period longer than 130 days

ECONOMIC IMPORTANCE

According to FAO estimates the average annual world production during 1999–2003 was 593 million t paddy (unhusked grain) from 153 million ha. Asia accounts for 90% of the world production and area. During 1999–2003 tropical Africa produced on average 11.9 million t paddy (2% of world production) annually on 7.7 million ha (5% of world area); these data include African rice (*Oryza glaberrima* Steud.), which occupies less than 20% of the rice area in West Africa. Nigeria produced 3.5 million t from 2.9 million ha. Thailand is the world's largest exporter of milled rice (26% of world trade during 1998–2002) followed by Vietnam, India, the United States, China and Pakistan.

Main rice importers are Nigeria, Senegal and Côte d'Ivoire. Per capita annual milled rice consumption in tropical Africa varies tremendously between 0.15 kg and 95 kg with an average of about 18 kg for the period 1998–2002.

CULTIVATED SPECIES.

The New Rice for Africa (NERICA) has been spreading rapidly in sub-Saharan Africa(SSA) since the seeds of the high yielding rice varieties was introduced in 1996. In 2006, a onservative estimate of area grown to NERICA varieties in SSA was about 200,000 hectares.

West African rice ecosystem are conventionally classified as irrigated, rainfed-lowland, rainfed-upland, mangrove swamp and deep-water systems. The total area under rice cultivation is currently about 4.4 million hectares (ha), with the rainfed upland and rainfed lowland ecosystems each accounting for about 1.7m ha and irrigated rice for another 0.5m ha, making these the high-impact ecologie

Total area (hectares) under rice cultivation in various ecologies in Nigeria.

Country	Total area (ha)	Mangroove swamp	Deep water	Irrigated lowland	Rainfed lowland	Rainfed upland
Nigeria	1,642,000	16,420	82,100	262,720	788,160	492,600

Source: Lançon F. and O. Erenstein (2002).

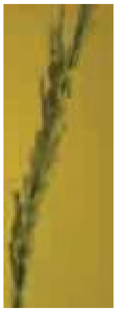
NERICA

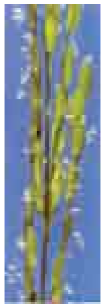
NERICA growing very well in a farmer's field (WARDA, 2006)

NERICA is a genetic material derived from successful crossing of the two species of cultivated rice, the African rice (O. Glabberima steud.) and Asian rice (O.sativa L.) to produce a progeny (known as interspecifics) that combines the best traits of both parents. These includes high yield from the Asian parent and ability from the African parent to thrive in harsh environment.

O.Sativa as female parent

O.Glabberima as male parent





NERICA is produced through conventional crossbreeding and therefore not a genetically modified rice.

In 2000 WARDA named NERICAS 1-7 and in December 2005 WARDA named upland NERICAS 8-18.

Other improved varieties.

- ITA 150 * ITA321 * ITA360
- ITA235 * ITA257 * ITA128

MORPHOLOGICAL DESCRIPTION

Annual grass up to 1.8 m tall (up to 5 m long in some floating types), forming small tufts; roots fibrous, arising from the base of the shoots; stem (culm) erect or ascending from a geniculate base. Leaves alternate, simple; sheath coarsely striate, tight when young, later somewhat loose, ligule 1.5–3 cm long,; auricles often present, falcate, 1–5 mm long. Inflorescence a terminal panicle up to 50 cm long, erect, curved or drooping, with 50–500 spikelets; branches solitary or clustered, nearly erect to spreading. Spikelet solitary, asymmetrically oblong to elliptical-oblong, 7–11 mm × 2.5–3.5 mm. Fruit a caryopsis (grain), ovoid, ellipsoid or cylindrical, 5–7.5 mm × 2–3.5 mm, often whitish yellow or brown to brownish grey.

ECOLOGY

Rice grows on dry or flooded soil and at elevations ranging from sea level to at least 2400 m. The average temperature during the growing season varies from 20–38°C. Night temperatures below 15°C can cause spikelet sterility. Temperatures above 21°C at flowering are needed for anthesis and pollination. Upland rice requires an assured rainfall of at least 750 mm over a period of 3–4 months and does not tolerate desiccation. Lowland rice tends to be concentrated in flat lowlands, river basins and deltas. The average water requirement for irrigated rice is 1200 mm per crop or 200 mm of rainfall per month or an equivalent amount from irrigation. Traditional cultivars are generally photoperiod sensitive, and flower when daylengths are short (critical daylength of 12.5–14 hours). Many modern cultivars are photoperiod insensitive.

The soils on which rice grows vary greatly: texture ranges from sand to clay, organic matter content from 1–50%, pH from 3–10, salt content up to 1%, and nutrient availability from acute deficiencies to surplus. Rice does best in fertile heavy soils. The optimum pH for flooded soil is 6.5–7.0. The often sandy texture of soils in tropical Africa is a constraint to productivity due to drought stress, low inherent soil fertility and leaching. Groundwater salinity problems occur in the dry Sahel zone where rice is grown under irrigation.

PROPAGATION AND PLANTING

Rice is propagated by seed. The 1000-seed weight is 20–35 g. The seed may either be broadcast or drilled directly in the field, or seedlings may be grown in nurseries and transplanted. Direct seeding is done in dry or puddled soil. In puddled soil the (pre-germinated) seeds are broadcast. After sowing the water level is kept at 0–5 cm under tropical conditions. In dry soil the seeds are sown just before or after land preparation. In the latter case the seeds are then covered lightly with soil. The seeds are sown just before the rains begin and germination occurs after heavy continuous rains. This method makes it possible to have initial crop growth from early rains.

In tropical Africa various rice-growing systems are distinguished:

– Upland rice, which may be subdivided into dryland rice, whereby moisture supply is entirely dependent on rainfall, and hydromorphic rice where the rooting zone is periodically saturated by a fluctuating water table, in addition to rainfall;

– Lowland rice, including mangrove swamp rice along the coastal regions with tidal intrusion, inland swamp rice on flat or V-shaped valley bottoms with varying degrees of flooding, and rice

on bunded fields under rainfed or irrigated conditions;
– Deepwater rice, in which the rapid growth of the internodes keeps pace with the rising water up to 5 m or more, starting from 50 cm of standing water.

In upland rice cultivation the fields are normally cleared through the slash-and-burn practice. Soil preparation is normally minimal. The rice is broadcast or dibbled when the rains start. It is often grown as the first crop in rotation or intercropped with other crops such as cassava, maize, sorghum, cowpea, groundnut and other pulse crops.

In lowland rainfed-rice areas the land is mostly prepared while it is wet and only in rare occasions when it is dry. The wetland tillage method consists of soaking the land until the soil is saturated, ploughing to a depth of 10–20 cm using a plough drawn by oxen/small machines or by using a hand hoe, preferably when there is a little water on the land, and harrowing, during which big clods of soil are broken and puddled with water. The important benefits of puddling include the apparent reduction of moisture loss by percolation, better weed control, and easy transplanting. In lowland rice cultivation seedlings are mostly raised on wet nursery beds and sometimes on dry nursery beds. Wet nursery beds are made in the puddled or wet field. Normally farmers use 50–60 kg of rice seeds to plant one ha. Seeds are pre-germinated and spread on the bed which is kept constantly wet. Dry nursery beds are prepared near the water source before land preparation. The seeds are sown and then covered with a thin layer of soil and watered until saturation for uniform germination. Further watering is applied as needed. In both cases the seedlings are ready for transplanting 20–35 days after sowing. At transplanting heavy tillering cultivars in fertile valley bottoms are wider spaced (30 cm × 30 cm) than slightly tillering cultivars in upper, sandy fields (20 cm × 20 cm). The spacing in irrigated rice is normally 20 cm × 20 cm with 2–4 plants per hill (500, 000–1,000,000 plants/ha). Rice is generally a sole crop under lowland conditions. Near harvest, relay planting is rarely practised. In many parts of the tropics 2 or even 3 crops of rice can be grown per year.

GROWTH AND DEVELOPMENT

Rice seed germinates in 24–48 hours. The optimum temperature for germination is 30–32°C.. Ten days after germination the plant becomes independent as the seed reserve is exhausted. Tillering begins thereafter, although it may be a week later in transplanted seedlings. In modern cultivars with an average maturation period, maximum tillering stage is attained around 45 days after transplanting and coincides with panicle initiation. The duration of the vegetative stage ranges from 7 to more than 120 days. The reproductive stage starts at panicle initiation, and the period from panicle initiation to flowering is around 35 days. Rice is almost 100% self-pollinating, but small amounts of cross pollination by wind do occur. It takes around 7 days to complete the anthesis of all spikelets in a panicle, starting from the top and progressing downwards. The period from flowering to full ripeness of all the grains in a panicle is usually about 30 days. Low temperature can delay maturity and high temperature accelerates it.

MANAGEMENT

The agronomy of rice is diverse due to the differences in cultivation systems. Growing of upland rice is usually relatively labour-extensive, but transplanting rice by hand in puddled soil is a labour-intensive operation. Weeding is generally not necessary in the first 2 weeks. Manual and chemical weeding are common practice

In the cultivation of lowland rice, the land is inundated from the time of planting until the approach of harvest. The water is supplied either by flooding during the rainy season, by growing the crop in naturally swampy land or by controlled irrigation. The water level is kept at a height of 5–15 cm to suppress weed growth and to ensure water availability. Continuous flooding at a static 2.5–7.5 cm depth is best. The fields may be drained temporarily to facilitate weeding and fertilizing. At flowering the water level is gradually reduced until the field is almost dry at harvest. Generally 1.5–2 m of water (rainfall plus irrigation) are required to produce a good crop. The period in which rice is most sensitive to water shortage is from 20 days before to 10 days after the beginning of flowering.

The amount of fertilizer used is usually 60–120 kg N, 10–20 kg P and 0–30 kg K per ha. Higher nitrogen rates are used during the dry season when solar radiation is higher and increase in grain yield is larger. Generally, nitrogen fertilizer is only topdressed, mostly before or at panicle initiation. Fertilizer is broadcast by hand.

The most common mineral deficiencies in rice cultivation are of nitrogen and phosphorus, with potassium and sulphur in limited areas and sometimes zinc and silicon on peaty soils.

The degree of mechanization is in general limited in rice cultivation in tropical Africa. Occasionally farmers use tractors or small two-wheel power tillers for land preparation and powered threshing machines during harvest.

For various reasons many rice fields are left fallow in the dry season. In areas with suitable climatic and soil conditions for dry-season cultivation, rice may be rotated with crops such as other cereals, pulses and vegetables.

DISEASES

Blast (*Pyricularia grisea*, synonym: *Pyricularia oryzae*). Although this disease is often related to drought stress and therefore especially severe in upland and drought-prone areas, it may also be severe elsewhere.

Bacterial leaf blight (*Xanthomonas oryzae* pv. *oryzae*),

Rice yellow mottle virus (RYMV, only found in Africa), Brown spot (*Cochliobolus miyabeanus*),

Leaf scald (*Microdochium oryzae*),

Sheath blight (*Thanatephorus cucumeris*),

Narrow brown leaf spot (*Cercospora janseana*)

Sheath rot caused by *Sarocladium oryzae*.

Nematodes attack roots and young, unfurled leaves and reduce rice production in certain parts of tropical Africa.

PESTS

White stem borer (*Maliarpha separatella*),

Pink stem borers (*Sesamia* spp.)

Striped stem borer (*Chilo* spp.). Damage results from larvae feeding within the stem, severing the vascular system.

Dead heart is the damage to the tiller before flowering.

White head is the damage after flowering which causes the entire panicle to dry.

Stalk-eyed fly (mainly*Diopsis macrophthalma*) resembles the dead heart damage from stem borers as it generally attacks the rice plant at the early tillering stage.

Gall midge maggot (*Orseolia oryzivora*) stimulates the leaf sheath to grow into a gall and tillers with galls do not bear panicles.

Termites and mole crickets attack rice plants especially in rainfed upland rice.

Pests of stored rice are the rice weevil (*Sitophilus oryzae*)

Grain borer (*Rhyzopertha dominica*). These insects can completely destroy the grain.

HARVESTING.

Grain should be harvested before it is fully mature (around 21–24% moisture), usually about 30 days after flowering, or when 90% of the grains are firm and do not have a greenish tint. Wetting and drying cause grain cracking, cracks being formed more readily when the grain is quite hard. Harvesting by hand, the commonest method, is very labour-intensive. In some areas a small knife is used, but in many areas farmers use a sickle to cut the panicles plus some or all of the culms. Mechanical harvesters are very rare in tropical Africa. The harvested rice plants are either allowed to dry in the field or bundled for processing in a selected area.

YIELD

Average rice yields are 1.4 t/ha in tropical Africa, 4.1 t/ha in Asia and 4.0 t/ha in the world in general. Yields are generally higher during the dry season than during the wet season, and higher in lowland rice than in upland rice. The yield of upland rice varies between 0.5 and 1.5 t/ha in tropical Africa

HANDLING AFTER HARVEST

Threshing is generally done by hand, by beating the bundles on a stone or drum, or by beating the panicles with wooden sticks on a canvas. However, motorized and pedal-driven threshing machines are becoming popular. Winnowing is usually done by shaking and tossing the grain on a basket-work tray with a narrow rim.

Proper drying of the rice grains is important to prevent germination and rapid loss of quality. Optimum moisture content for storage is 12.5%. Rice grain is mostly stored in sacks after drying. In rice milling the aim is to avoid breaking the kernels because whole kernels command a higher price. There are different methods of milling. On milling, the grain gives approximately: husk 20%, whole kernels 50%, broken kernels 16%, bran and meal 14%. The husked or hulled rice is usually called brown rice, and this is then milled to remove the outer layers, after which it is polished to produce white rice. During milling and polishing some of the protein and much of the fat, minerals and vitamins are removed, reducing the nutritional value but increasing storability and reducing cooking time. Parboiling (soaking, boiling and drying) before milling improves the nutrient value of the grains but it is not common in tropical Africa.

NUTRITIONAL COMPOSITION

Raw brown rice contains per 100 g edible portion: water 13.9 g, energy 1518 kJ (363 kcal), protein 6.7 g, fat 2.8 g, carbohydrate 81.3 g, dietary fibre 3.8 g, Ca 10 mg, Mg 110 mg, P 310 mg, Fe 1.4 mg, Zn 1.8 mg, thiamin 0.59 mg, riboflavin 0.07 mg, niacin 5.3 mg, vitamin B_6 0.56 mg, folate 49 µg, ascorbic acid 0 mg.

Raw polished rice contains per 100 g edible portion: water 11.7 g, energy 1536 kJ (367 kcal), protein 6.5 g, fat 1.0 g, carbohydrate 86.8 g, dietary fibre 2.2 g, Ca 4 mg, Mg 13 mg, P 100 mg, Fe 0.5 mg, Zn 1.3 mg, thiamin 0.08 mg, riboflavin 0.02 mg, niacin 1.5 mg, vitamin B_6 0.30 mg, folate 20 µg, ascorbic acid 0 mg (Holland, Unwin & Buss, 1988).

USES

The rice grain is cooked by boiling or steaming, and eaten mostly with pulses, vegetables, fish or meat. Flour from rice is used for breakfast foods, baby foods, bread and cake mixes and cosmetics. Starch made from broken rice is used as laundry starch and in foods, cosmetics and textile manufacture. Beers, wines and spirits are made from rice.

The husk or hull is used as fuel, bedding, absorbent, packing material and as carrier for vitamins and drugs; it is also made into building board. The charred hull is used for filtration of impurities in water, a medium for hydroponics and manufacture of charcoal briquettes. Rice bran or meal obtained in pearling and polishing is a valuable livestock and poultry feed. Oil is extracted from the bran. Rice straw is used for animal feed and bedding, for the manufacture of straw boards and pulp for paper, for the production of compost and mushroom growing medium, for mulching vegetable crops, for making ropes, sacks, mats and hats, for roof thatching, and to make plastering material (mixed with clay mud) for the construction of houses, and for incorporation into the soil or burning on the field as a way to maintain/improve soil fertility.