Organisation: International Rice Research Institute, Philippines (IRRI)
Author: Ray Lantin
Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis (Language&Style), Carolin Bothe (HTML transfer)

CHAPTER X RICE: Post-harvest Operations

3. Overall losses

Postproduction losses of rice can be quantitative or physical which means a reduction in weight or volume of the final usable product from the potential yield or harvestable paddy. The losses can also be qualitative which means a reduction in value of the usable product due to the physical and chemical changes which diminish the grain size, cause poor appearance, taste, aroma, cleanliness due to admixtures or contaminants and chemical residues and other factors which the consumers of the product will otherwise undervalue or the grain standards authorities will degrade resulting in low demand for the product, low price or rejection and declaration as unfit for consumption by human or animal.

Losses are incurred in pre-harvest and post-harvest processing operations consisting of harvesting, threshing, cleaning, drying, storage, transportation and milling. The flow chart of loss components of each operation are shown in Figure 4.0.1, Annex 4.0 F. The theoretical estimated losses of rice incurred in each operation are shown in Table 4.0.1, Annex 4.0 T.

Values of loss percentages for the different post-harvest operations by method in each operation in China, Indonesia, and the Philippines are respectively shown in Table 4.0.2, Table 4.0.3 and Table 4.0.4, Annex 4.0 T. Losses of rice within the post-harvest system in the developing countries of Asia, West Africa and Latin America are shown in Table 4.0.5, Annex 4.0 T.

The percentages of loss components incurred in different methods of harvesting, threshing, and storage in Zheijang, China during 1987-1989 have been documented by Ren-yong et al., 1990 and values are given in Figure 4.0.2, Figure 4.0.3, Figure 4.0.4, and Figure 4.0.5, Annex 4.0 F.

The following summarises the wrong practices in each major field operation and processing activity lead to physical grain losses:

(a) Pre-harvesting

1. Planting varieties with admixtures of red rice, which are highly shattering, have low resistance to lodging and uneven maturity dates;

2. Poor weed, rodent and bird pest controls;

3. Harvesting too early or too late of the variety maturity date.

(b) Harvesting

1. Missing the secondary tiller panicles because harvesting by sickle of lowland rice is done by cutting the straw about 60 cm above the ground;

2. Delay in harvesting causing shattering losses during harvesting and transporting and handling of the harvested crop before threshing;

(c) Threshing

1. When threshing manually by beating the harvested crop against a wooden plank, some more rice grains remain in the threshed crop. In some countries, these bundles are threshed once again by treading with animal;

2. Rice grains scatter around when lifting the small bundles just before the manual threshing above;

3. Some grains stick to the mud floor and cannot be recovered;

4. Birds and domestic fowls feed on the grains.

Summary notes on field operations The following are some choices of technology which is characterised by the degree by which grain could be lost. Manually beating the panicles on a drum or wood block will shatter grains and needs a wide threshing mat. A portable manual threshing platform enclosed by cloth or plastic sheet or fine net will contain shattering. A pedal-operated thresher increases threshing productivity and minimises shattering losses. An engine-powered axial-flow thresher combines threshing and cleaning in most designs but inefficient designs could lead to non-thorough separating and cleaning functions. An engine-powered stripper harvester combines harvesting and threshing and minimises handling losses but can lead to substantial grain losses if the crop is lodged and the field is wet and has poor trafficability.

(d) Drying

1. Grains shatter from the stalks or spill out of the grain bags during transport and handling;

2. During sundrying, birds and domestic fowls feed on the grains; grains spill outside the drying area;

3. Overdrying the grain, especially when sundrying by traditional method;

4. Delayed drying or no grain aeration which causes stackburning.

(e) Storage

1. Stored grain is attacked by insect, rodent and bird pests due to

inadequate protection;

2. Storing for long term, grain with moisture content above 14 percent or storing grain with moisture content of 18 percent longer than two weeks under ambient conditions;

3. Theft and pilferage in grain warehouses.

The farmers in Lao PDR store paddy in bags or in bulk on a roofed elevated platform with removable stairs and supported by six posts. The walls are made of woven or pounded bamboo mat or slats. Rodents are kept out by enveloping each post by a galvanised iron sheet cone guard or a circular horizontal wooden plate barrier.

(f) Milling

1. Improper adjustments of milling equipment;

2. Spillage in traditional hand pounding methods;

3. Under or over-dried paddy.

Summary notes on off-field operations. Sundrying, the most widely used drying method for home-consumed rice by farming families in developing countries, needs concrete pavement facilities. Table 4.0.6, Annex 4.0 T gives values of losses in drying and storage.

Insect pests can not only cause physical losses but also affect the nutritive value of stored rice. Table 4.0.7, Annex 4.0 T gives the estimated losses in samples infested by *Sitophilus oryzae*.

The theoretical milling recovery is 71-73 percent, depending upon the variety of rice. In a well -operated modern mill, it is possible to obtain a milling recovery of 68-70 percent from a good variety of paddy.

Milling losses can be reduced by adopting small-scale modern rubber roll sheller and introducing parboiling of paddy before milling. The suggested mill for village level is cleaner ---- rubber roll sheller --- horizontal abrasive polisher. This combination is expected to give 66 percent milling recovery.

PAGE < TOC PAGE >

INPhO e-mail: inpho@fao.org
INPhO homepage: http://www.fao.org/inpho/

Organisation: International Rice Research Institute, Philippines (IRRI)
Author: Ray Lantin
Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis (Language&Style), Carolin Bothe (HTML transfer)

CHAPTER X RICE: Post-harvest Operations

---

4. Pest control.

The estimated grain losses in storage due to pest infestation account for some 0.35 - 4.55 percent out of the total estimated grain losses in the post-harvest system of 2.63 - 31.3 percent. An insect population attains pest status through invasion, ecological changes and economic changes.

Invasion. The development of international trade has contributed greatly to the widespread habitat of insect pests. It is therefore important that the strict quarantine be part of the pest control system in a country.

Ecological change. The use of wide spectrum pesticides has reduced the population of natural enemies such as predators and parasites of major rice storage pests. The conditions therefore become more favourable to the rapid multiplication of major pests.

Socio-economic changes. The economic threshold is determined by market value of the grain, cost of control measures and consumer habits and taste. The rice damaged by a certain insignificant pest may lessen in value because of reduced tolerance of people for such condition of the commodity. The pest therefore becomes a significant or serious pest, although its population density did not change.

4.1 Relative status of major pest species

A pest is major if it is found in great number or in abundance. The rice weevil and the flour beetle are examples of such pest. A pest is minor if it is found in small number. A pest is primary if it attacks undamaged or sound grain, completes its development in it and initiates a chain of events in which other insects, fungi or bacteria feed on the damaged grain. The rice weevil is a primary pest. A pest is secondary if it attacks grain damaged or processed mechanically by grinding, milling, and handling or by the action of primary pests. The flour beetle, saw-toothed grain beetle and the rice moth are secondary pests.

4.1.1 Details of each major pest

(See Table 5.2.1, Annex 5.2).

4.2 Pest Control

Pesticide residues. (See Table 5.3.1, Annex 5.3).

Integrated pest management (IPM).

IPM is the use of all available tactics in a program to manage pest problems and minimise economic damage and environmental side effects (NAPHIRE, 1997). It involves the integration of biological, chemical and physical methods ones to control pests as well as other suitable and compatible to the system to keep the pest population at a level that will not cause any economic damage. The IPM program is built around the concepts of efficient warehouse design, high standard hygiene, minimum use of insecticides, use of methods that obtain as complete kill as practical and thorough inspection program.

The warehouse or storage structure at any level or size should protect the grain from water and moisture, keep the pests out or given no access for entry, facilitate loading and unloading, and be conveniently sited for handling and transport. A high standard of cleanliness and strict hygiene will prevent the build-up of damaging pest population by denying the pests of food and reduce the residual populations of insects and rodents in grain stores, surroundings and machinery. The program will also avoid seeding of clean grain with insects and infestation of adjacent stores as well as reveal possible structural weaknesses and paths ingress of water and soil moisture into the store.

The restriction of the use of pesticides to combinations with other control methods will enhance the oval effectiveness of the pest control program. Such restriction will help in reducing the potentially harmful residues, selection for resistance, environmental hazards and cost of treatment.

The complete kill is important in delaying population build-up and in reducing the rate of selection for resistance. Proper fumigation will control established infestations and in combination with barrier sprays of residual insecticides, will protect the grains against re-infestation.

Inspection and sampling activities are the means to obtain accurate qualitative information and data on the status of infestation of the grain. A pest and damage monitoring system is important in the overall efficiency of the pest control measures.

Elements of IPM

There are four basic elements of IPM, namely, natural control, economic levels, sampling and insect biology and ecology.

Naturally occurring growth suppressive factors may be utilised. The gas composition may be manipulated to hinder the growth and development of the pest

The economic threshold level (ETL) rather than the calendar-based application of pesticides will minimise the use of harmful chemicals and maximise the use of no-chemical methods of control.

The status of pest infestation, damage, level of losses and the population of beneficial insects and population trends of the harmful ones are determined by sampling which is a tool to apply ETL.

The knowledge of the biology and ecology is essential in utilising effectively the above three elements.

Components of IPM

The following components are utilised in the practice of IPM:

Biological control. The pest is controlled by a parasitoid, a predator or a pathogen to manipulate the reproductive processes, behaviour, feeding and other biotic aspects of the pest. A parasitoid resides and feeds on the host pest itself which eventually dies. An example is *Anisopteromalus calandrae* a small wasp which feeds on the beetle larvae of *Sitophilus spp*. and *Rhyzopherta spp.* A predator kills and feeds on one or more hosts and seldom resides or rides on them. A pathogen is a disease-causing organism, which is normally targeted specific and harmless to non-target organisms. It is easy and cheap to culture. Pheromones are chemical messages released by organisms to influence the behaviour (usually sexual) of the other organisms of the same species. Pheromones may be employed as attractant to prevent mating of the target species by misleading them. Host resistance to insect attack makes use of the natural built-in protection. For example, it is more advantageous to store rice as paddy than as milled rice because of the protective husk. Some varieties may have degree of tightness of the husk, which make them either susceptible or resistant to certain pest species. The use of sterile insects may be effective but it is resisted by those concerned. Neem (Azadirachta indica) leaves are used as insect repellent in the grain store in Indian households.

The constraints on the potential use of biological control of stored grain pests have been cited as follows:

(a) Predators, parasites and sterile insects found among the grains are themselves contaminants;

(b) Chemicals used to treat grains in store are toxic also to the beneficial insects;

(c) Predators and parasite attacks on pests are usually limited to the superficial layers of the large bulk of the stored grain;

(d) Pathogens do not thrive well in conditions of grain stored according to the recommended practices;

(e) Consumer rejection of the pathogen-contaminated rice.

Physical control. The physical method of controlling pests in storage includes the following:

(a) Hygiene and physical removal of infestation nuclei, including commodity residues, secondary or unproductive primary hosts for field pests. Cleaning should involve brushing and washing and disposal of all residues containing or supporting live insects. The rice mill machinery and premises are always a potential hosts of insects and should be cleaned regularly with special efforts made before any long gaps in operation to prevent the old and new resident pests from multiplying before the next milling season comes.

(b) Physical exclusion of the pests from the stored grain in the form of hermitic and controlled atmosphere storage requires gas tightness to be effective. Gas tightness through sealing is effective not only in keeping insects out but also in fumigation, single-treatment controlled atmosphere and heat disinfestation.

(c) Drying hinders the attack of most insects and fungi on the stored grain.

(d) Cold ambient temperatures during harvest and storage reduce the activities of insects. Refrigeration is the alternative in places like the tropics to take advantage of the effect of low temperature on insect pests.

(e) Aeration with cold ambient air as a means of effectively controlling pests in cold and temperate climates will not be as effective in semi-tropical and tropical conditions where temperatures are above 15 to 18^{o}C required to prevent rapid increase of insect population. However, aeration of the grain bulk can be effective in preventing local hot or wet spots, which favour insect growth and development.

(f) Hermetic (airtight) storage confines the grain inside a sealed enclosure wherein the respiration of the grain and the associated insects and fungi will deplete the oxygen and replace it with lethal amounts of carbon dioxide generated by them. The process is simple, self-regulating, and requires no added pesticides, inert gas or energy inputs. Maintenance of the hermetic seal of the storage structure and moisture migration are problems involved in this method. Studies of the use of plastic enclosure for outdoor storage intended to be used by farmers' co-operatives and small-scale traders and millers were conducted by NAPHIRE (1997) in collaboration with the Commonwealth Scientific and International Research Organisation (CSIRO) of Australia and the Agricultural Research Organisation (ARO) of Israel. Results indicated that paddy at 14 percent moisture content could be stored for three months without being damaged. The locally available nylon fibre-reinforced polyvinyl chloride (PVC) plastic material of thickness 0.60 mm could be used for five years. The capacity of the heat-welded enclosure was 6 tons of paddy. The volcani cube (Israel) made of PVC food grade liner of 0.83 mm thickness and closed by polyurethane zipper, could be made for capacities of 5, 10 and 20 tons of paddy. The volcani cube could be re-used and last for 10 years provided that it is cleaned and properly stored after each use.

(g) Controlled atmosphere which although similar in form to hermetic storage, is different from it in that the carbon dioxide gas is supplied from the outside. Storage period could last from 9 to 16 months. No risks of toxic chemical residues are present.

(h) Inert dusts in the form of ground rock or wood ash have been used to control insects in subsistence level grain storage systems. They may be used at rates above 30 percent of the weight of the grain. Dusts made of silica aerogels, various clays, diatomaceous earth, activated carbon, pyrophylite and a number of other silicates kill insects by absorbing or abrading the waxy layer from their cuticle causing desiccation and death. Dusts do not eliminate the residue problem although they are not toxic. They are unpleasant to handle. Promising inert dusts for on-farm storage in developing countries are the low-cost and easily applied silica aerogels and the diatomaceous earth as they are not toxic.

(i) Physical shock and disturbance can kill insects due to physical stress and damage due to handling and processing of the grain.

(j) Artificial light regimes can affect the photoperiodic responses and mating of insects. However, the potential for response by insects to visible, ultraviolet and infrared radiation for control has yet to be realised.

Chemical control. Chemical control methods have the advantage of effectiveness, simplicity, versatility, low cost and immediate availability. However, synthetic insecticides must be regarded as adjunct to good warehouse management, to reinforce hygiene and sanitation, to enhance effectiveness of available storage facilities, and to complement physical methods. It is not intended to replace good warehouse keeping or regular inspection for infestation or deterioration. The main types of insecticide treatment are as follows:

(a) Structural treatment (residual spray application). The surfaces of warehouses, storage bins, transport vehicles and other structures and machinery are sprayed with chemical which will not only kill the insects directly hit by the spray but will also leave a deposit on the treated surface which will be toxic to walking insects. Spraying may be done during the cleaning of the storage facilities before intake of new stocks or along with fumigation or spraying of stock in storage. The residual deposit decays with time and its effectiveness depends on the chemical and the climatic conditions prevailing.

(b) Space treatment. Fogging or space spraying is intended to control flying insects not controlled by the residual spray and those coming into the storage warehouse. Spraying is done usually at dusk hen insects are most active. Chemicals with knockdown action such as pyrethrin, lindane, and dichlorvos aerosols and strips or smoke or fog are used in space spraying. Dichlorvos plastic strips hung inside the warehouse at a density of 1 strip /30 cubic meters of space will be effective for flying moths.

(c) Grain protectants. These insecticides will prevent infestation when applied on grains. It is intended for light infestation only at the time of treatment and is not a substitute for fumigation in case of heavy infestation. In general, it should be avoided as it may accelerate the selection of resistant strains. The choice of insecticides to use is quite limited, as safety should be a prime consideration. Studies by Sayaboc, et al., 1996, of resistance of major insect pests to pyrethroids and organophosphates, revealed high resistance of the lesser grain borer *(Rhyzoperhta dominica)* to phosphine, in contrast to the low resistance of flour beetle *(Tribolium castaneum)* and susceptibility of rice weevil (*Sitophilus oryzae*).

(d) Surface spraying. The insecticide is applied on the surfaces of bulk grain or bags of grain. Examples are pyrethrum synergized with piperonyl butoxide, pirimiphos-mythl, chlopyrifos-methyl, tetrachlorvinphos, fenithrothion and metacrifas at about 1 to 2 percent concentration.

(e) Fumigation. A fumigant is a volatile pesticide, which exerts toxic action in the gaseous or vapour phase. The most common fumigants used world-wide are methyl bromide and phosphine. Fumigation is effective because of thoroughness of application but fumigants used to control pests are generally toxic to humans and plants; may be corrosive, flammable, leave harmful residues and produce offensive odours. In application, it is best to monitor the atmosphere inside the warehouse with appropriate test equipment and the threshold limit value should conform with that recommended by the American Conference of Government Industrial Hygienists (1983-1984). The most common deficiency in fumigation is the neglect of hygiene and stock management resulting in the necessity of frequent fumigation and consequently, the hazards of excessive bromide residue accumulation in the grain. Phosphine complements the use of methyl bromide, especially in vertical storage, Sayaboc et al., (1996) found that the use of 2 g phosphine per ton of grain at seven-day exposure time will effectively control insects at all their life stages. Other fumigants, which are used occasionally, are hydrogen cyanide, carbon disulfidem ethylene dibromide, chloropicrin, methyl chloride and carbon tetrachloride. A tolerance value of 0.1 ppm expressed as PH_3 , is recommended in international trade of cereals.

Two or more components of pest control can be combined in an integrated program. However, in a storage ecosystem, hygiene and good warehouse management are basic requirements and the IPM system is but supplementary. The combination of two or more of the following practices will constitute an effective pest control program.

(a) Improved harvesting and threshing techniques;

(b) Judicious use of insecticides;

(c) Use of ambient aeration and refrigerated aeration;

(d) Atmospheric gas modification;

(e) Thermal disinfestation;

(f) Irradiation techniques;

(g) Insect resistant packaging;

(h) Insect growth regulators;

(i) Biological control;

(j) Use of resistant varieties.

PAGE < TOC PAGE >

INPhO e-mail: inpho@fao.org
INPhO homepage: http://www.fao.org/inpho/

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

PAGE < TOC PAGE >

Organisation: International Rice Research Institute, Philippines (IRRI)
Author: Ray Lantin
Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis (Language&Style), Carolin Bothe (HTML transfer)

CHAPTER X RICE: Post-harvest Operations

5. Economic and social considerations

The straightforward method by which farmers can add value to the paddy is by drying it to a marketable moisture content. In most of the tropics the equivalent moisture content is 14 percent wet basis. When paddy is dripping wet as in the case when harvest time occurs during monsoon rain and a series of cloudy days will likely follow the rainy days, it is critical that the moisture content of the paddy be reduced to skin dry condition within 24 hours after harvest. An interim safe moisture content is 18 percent for a 2-week storage under dry and protected conditions or at most 20 percent for a few days storage with occasional stirring and aeration. The choice of how far down the moisture content should go depends on the urgency of reducing the moisture content of the bulk of the grain to a safe moisture level. A flash dryer will remedy the situation on an emergency basis. This moisture content will at least be a first aid in saving the paddy from deterioration and will give the farmer enough time to organise and implement a drying system or sundrying depending upon his resources. Under most circumstances however, the farmer will opt to sell the paddy at a low price to a trader or rice mill because the small holder is generally averse to risks. The alternative is government action to provide drying and storage facilities at strategic areas. This is what the grain agencies like BULOG in Indonesia and the NFA in the Philippines are doing to a limited extent. These government agencies also encourage the formation of farmers' co-operatives in rice milling with drying facilities.

For very small holders, the problem of saving the wet grain harvested during the monsoon rains needs to be solved. Even if there were a government facility for drying paddy, the small quantity and most often the cost of transporting the paddy becomes an additional financial burden which the marginal farmer will not likely take. An option is to aerate the small amount of paddy by piling it into small heaps to expose as much surface area of the grain to the atmosphere and prevent heating up of the bulk due to microbial action and grain respiration. This procedure will require frequent turning over of the grain. A meticulous farmer will even scoop out the thin upper layer of each heap to form another heap, which is drier than the grain beneath and at the bottom especially with an initially dripping wet grain. If available, a manually or pedal-operated blower or engine-powered blower used for field winnowing may be used to increase the aeration process. A household electric fan will also be useful and in fact being used by farmers. It is best to have the bottom of the heap to be resting on a fine mesh net on a platform with slatted floor to increase underneath aeration and to drain any gravity moisture from the grain heap. These are emergency measures for the small holder and will be impractical or will require much labour or space for a commercial scale operation. Nevertheless, in the absence of drying facilities the above procedure can be adopted as an emergency measure or first instance solution until favourable sundrying weather comes.

The rising cost and non-availability of labour due to increasing employment opportunities in industry in some developing countries, particularly in Asia, has increased the adoption of mechanisation of rice production and post-harvest operations. The small size of fields, however, limit the powered machines to pedestrian tractors and machinery which also determine the scale and method of operations in harvesting, threshing, in-field handling and field-to-road paddy and straw transport of paddy.

Unless major policy directions leading to more efficient field operations than in the small-sized fields are instituted, the field operations in harvesting and threshing will likely remain as it is for a long time although small-scale powered machines will increasingly be utilised. One of such policy directions is the land reformation and consolidation as has been done to some degree in Japan and in Taiwan, province of China. Due to increasing demand for small-scale machinery mainly for custom service operations by small village entrepreneurs, the local manufacturing industry has been progressing and gradually increasing the quality of farm machines as well making them more affordable than before. In most developing countries, the power unit, the small engine ranging from 5 to 10 kW, remains as an imported item and is a major high cost component of a machine. However, a given engine may be used for a variety of small machines ranging from land preparation, crop establishment and care, irrigation, harvesting, threshing, transport, drying, and perhaps, in-field hulling of paddy. An increased support in rice production and post-harvest machinery research and development as well as agricultural and industrial extension will eventually lead to minimised post-harvest losses and reduced costs. Improved timeliness and efficiency of operations resulting from appropriate machinery and its proper maintenance will redound to the benefit of the small holders.

The use of combines as a step towards mechanisation has had a forward linkage with post-harvest operations. The large volume of paddy being turned over to the processing plants in a short time has put pressure on the drying and storage facilities in Thailand, a major exporter of rice. Large capacity dryers are now being manufactured locally and have large demand, at least for the present. Because of lack of incentives for the farmer to dry paddy, the drying operation will continue to be an adjunct operation of rice milling and will take place at the rice mill site using mechanical dryers combined with mechanised sundrying whenever feasible because of its low cost especially due to free, albeit unreliable (during rainy season) heat energy. Sundrying with complementary mechanical drying will be a main drying operation to take advantage of the sun's free heat energy and the environmental friendly feature of the technology. Mechanised and precision-controlled sundrying (still a neglected area for technological innovations, though sundrying is widely used) in combination with artificial or forced-heated air-drying is a pertinent subject of research and development now and in the future.

The concept of increasing the income of small holders through value-adding in paddy or engaging in primary post-harvest operations at the farm level remains a question under the present system of low incentives or non-recognition of such added value either by design and necessity or by trade practices in most developing countries. The farmer will have larger margin of profit and therefore incentive if he dries paddy during the wet season. Only a few farmers will recognise and adopt this concept, as some sort of drying facilities will be needed. A government campaign and assistance will perhaps make more farmers adopt the value-adding concept rationalising that social benefits will accrue in terms of lessened post-harvest losses, better grain quality and self-sufficiency in the staple. Perhaps the more easily adopted technology is to make the production and field harvest and post-harvest operations of threshing, handling and transport more efficient through better infrastructures and this is also normally a government initiative and at best a community action.

5.1 General overview

Once the rice crop has produced the grains approaching the potential yield for the variety under a given cultural practice, soil and climatic conditions as well as a set of inputs and other factors in production, the actual amount of grain finally retrieved from the plant after all stages of processing does not normally match that yield. There are numerous ways by which that yield already in the plant could be lost and so does the opportunity for it to be of use as food or something else. This situation occurs because there are many steps to be taken in bringing that yield from the plant to the rice bowl. Each step in the production and processing entails a certain degree of reduction depending upon the technology used and the care given to prevent or minimise losses. The rice crop losses are reported as lumped as percentage of the yield per hectare.

The post-harvest operations begin at harvest and ends at the storage of the milled rice. The range of processes discussed here does not consider the costs and losses in delivery of the rice to wholesalers and retailers from the rice mill, in cooking, and finally in serving the rice food in the plate or bowl of the consumer.

The grain losses in the field may be incurred during pre-harvest period and at harvest time. Normally, the longer the harvested grain is left in the field, the higher the chances of incurring grain quality deterioration and spoilage due to weather, stackburning and delays in drying as well as physical loss due to rodents, pilferage, and other causes. Depending on whether the variety is shattering or non-shattering, field losses of the grain may be small or large even if the rice crop is still standing. Wind, rain and degree of maturity of the crop can have a large effect on the magnitude of such losses for a given variety.

5.2 Major problems

Harvesting and threshing are major problems in field operations while drying of the paddy is critical as a post-harvest operation. Since milling is an industrial process which can easily be controlled inside a building, the problems related to this process are determined by the quality of the paddy received by the mill. The critical factor is the drying of the paddy immediately after harvest. In some developing countries, drying of the surplus paddy for the market is not normally carried out by the small-scale farmers. Wet or freshly harvested paddy is sold directly to traders or to the rice mills and rice milling co-operatives. Somehow, the farmers avoid the risk of crop deterioration by disposing off the crop immediately. The problem of drying is passed on to the trader or rice mill owner but the farmer gets a low price for the undried paddy. The bottlenecks in post-harvest processing should be solved using the systems approach.

In harvesting and threshing the quality of the harvested crop, the degree of losses incurred and the efficiency of the operations and hence, overall costs are affected by factors related to the weather, variety of the rice, and the technology used. Harvesting and threshing during the monsoon season bring about problems of wet and lodged crop, high moisture grain which is susceptible to spoilage due to fungal and microbial invasion, difficulty in threshing, grain handling and transport regardless whether the methods are mechanical or manual, and the critical need for immediate drying of the paddy. It is obvious that one problem in a process stage affects the quality and efficiency of the next stage and mitigating measures at that stage are needed. This chain reaction continues up to the milling process until the semi-final product, milled rice is produced.

The same problems appear to be magnified for small holders because of scarce resources to do mitigating measures like quick drying or transport to the market of wet paddy. They have lesser capability to absorb losses than the big landholders or commercial rice producers. They are forced to sell the paddy at very low price which may be the best thing to do under the circumstances to prevent greater losses, if not total loss.

5.3 Proposed improvements

The sale of the paddy, the final product from the farm, is the major if not only means by which the farmer, especially the small holder, can benefit from rice production. Straw, the only other by-product of rice production in the farm but has not been fully tapped by most farmers, except in places where it has market value as animal feed or thatch.

An increase in sales proceeds of means increased income. This increase in income can be achieved through increased quantity and improved quality of the product. Increased quantity is achieved through enhanced productivity of the cropping system and increased amount of production through improved production technologies as well as reduction of losses in the field. Improved quality of the paddy can be achieved essentially though variety selection in terms of eating quality, improved crop care (irrigation, pest and weed control), optimum harvesting time, and improved post-harvest processing. Field processing activities, including harvesting, threshing, cleaning and handling are more for retaining that quality or preventing grain deterioration rather than improving it.

Unfortunately, the small holder usually participates in the post-harvest processing stage only at harvesting, threshing and handling which may still be considered as the tail end of the farm production system because the product is considered as raw material and no value has been added so far. The concern is more of sustaining the quantity and the quality of the crop as produced, that is to add value and prevent the paddy from deteriorating.

The small holder does not have the capability or resources and the incentive (in many places) to do any further processing. Attempts by government extension services to promote drying at the farm level of paddy for sale have not been successful because the economic benefits for the farmers are not significant in terms of labour inputs and capital costs involved as well as the affordability to wait for higher prices of paddy. Any incentive from the paddy trading industry in terms of value or price increase given to the farmer to dry the paddy is usually very low, so that the farmer is forced to sell the wet paddy at a low price or else the paddy will deteriorate and will have zero or near zero value. The small holder family only dries the paddy retained at the household for immediate family consumption and for food and cash security at least until the next harvest.

After the field post-harvest procedures and activities have been optimised, such that production has been maximised, losses have been minimised, and the excellent quality of paddy have been attained, a possibility of the small holder increasing the cash income is an increased efficiency of the traders and millers of the traded rice in their operations and passing on part of the savings in costs to the small holder through better paddy prices. This is at best theoretical, as the traders and millers will likely keep the windfall from such efficiencies rather than share it with the producers or they are more likely to share such efficiencies to consumers. Only increased competition, increased market demand for rice or reducing supply by lowering production (indeed a counter-productive method) with no government intervention by importation of rice will increase the price of paddy.

Rice processing and trading co-operatives among farmers have been successful in many places in assuring farmers a fair price for their paddy and enabling them to get benefits from the processed and traded rice by virtue of their share of ownership of the processing facilities and the business. This strategy has been promoted by governments but is beset by problems of lack of management skills and capital investment costs. While there are success cases, there are also failures of attempts to organise and sustain rice processing co-operatives.

Perhaps an effective strategy is to empower the farmers to process the paddy (at least partly) in the farm by hulling it and trading the brown rice for further processing by the rice milling co-operatives or the private commercial mills. Brown rice can have a separate path leading to a niche market among the health-conscious consumers is developed countries. This alternative will entail not only innovative approaches to the technology but also changes in the pattern of field production, trading, storage and consumption of rice.

The reduction of field losses in harvesting and threshing can increase the profits of the small holder. Shifting from the manual to the proven efficient mechanical method of harvesting will greatly reduce harvest losses. The fast rate of harvesting and threshing enables a timely removal of the grain from the field which may be critical during the monsoon season. Drying the crop by the small holder aimed at increasing value of the paddy has not been a popular activity because of the low returns from the drying process. However, very wet paddy resulting from a rainy harvesting and threshing episode, will command a low price unless it is dried properly. In such a case the margin of profit may be high as the choice could be between a total loss or no profit and reduced profit due additional expenses in drying. Small portable axial-flow threshers which have been originally designed by IRRI are now being manufactured and distributed locally in many developing countries. Pedal-operated threshers have been accepted in the terraced fields in the highlands because of their portability and affordable costs, especially if made locally.

In Myanmar, the system of mechanical threshing has increased in popularity among farmers because of the significant benefits derived from their use. From observations in the adoption of mechanical technologies such as mechanical threshers in developing countries, the custom operation by a local entrepreneur who buys the machine such as a thresher, appear to be a popular and fast process. Custom services in threshing and cleaning of paddy benefit the farmer because of the faster output and cheaper rates. The system spares the farmer the investment and operational costs of the machine and may not be viable from the ownership consideration. The utilisation of the rice husk as domestic cooking fuel has increased in popularity in Myanmar perhaps because of the aggressive manufacturing and marketing by a local fabricator of a Vietnam-designed rice husk stove which has been modified by IRRI.

5.4 How has the introduction of the improved technology affected income/responsibilities between genders?

In most small rice farms in developing countries, women play a major role not only in production but also in post-production operations. In many countries, women are involved in or do most of the manual harvesting, threshing, winnowing, handling and sundrying drying. The men do the hauling and operate any powered machine if it is used while the women act as helpers.

In general, postproduction technology development and transfer programmes have been carried out on the assumption that the technology is either sex-neutral or that men are the main users and decision-makers. This assumption is often incorrect because women and other household members have quite different technology needs than men because of their different knowledge, experiences and skills, physique, stamina, etc.

Women workers are usually the first ones to be affected by a new technology introduced to improve processing. A powered machine will immediately displace women or relegate them into lesser tasks as helpers as the men take over the machine, be it a power tiller-mounted harvester or an engine-operated thresher. A pedal-operated thresher, however, fits the physique of women and is therefore accepted as a labour-saving device where mostly women do traditional harvesting and threshing.

Sundrying of paddy for household consumption is also a traditional task of women. Men do assist in the handling of the bags or containers. Since mechanical or forced heated air-drying is usually done by rice traders and millers, women are not much affected by such technology.

Most rural women in developing countries are traditionally responsible for pounding rice using the mortar and pestle or the beam hammer/pounder (*dheki*). Where the steel huller mills have been introduced, these traditional methods fade away. In most cases the substitution has been beneficial to the women because of the great relief from the arduous work or otherwise, because their family income has contracted. Sometimes, the change has given them the opportunity to explore other means of income generation, a luxury they could ill afford because their time is being used up by the major family obligation of milling rice which is just one of their several domestic tasks. At the worst perhaps, the displacement of women from their income generation of hand-pounding of rice for sale in the community (a marginal micro-enterprise at that), is temporary as some well-to-do community consumers would still prefer the pounded rather than the milled rice during the transition stage. With a small rice mill, such as IRRI micro-mill modified from a Chinese design, a women's group in the Philippines was able to increase income and obtain the bran for animal feed. The milling micro-enterprise was easily patronised by the villagers who were spared the time and effort to go to the far commercial rice mill to have their paddy milled. In effect, the introduction of the technology on a pilot basis has given economic and social benefits.

In a rural appraisal on the roles of the different household members in the postproduction of rice and other crops in Isabela and Quirino provinces in the Philippines, the following activities of women were observed (Paris and Duff, 1989):

Harvesting. Performing this task varied according to the culture and economic need of the family. In one village, men dominated harvesting because they were considered fast workers and could stand tougher jobs (exposure to sun or rain for long periods while at work). In another village of another province, harvesting was dominated by women and children (8-14 years old) because they were available or left behind during the harvest period as the men folk did the land preparation immediately after harvesting their own fields or worked as hired labour. In some cases, men looked for harvesting/threshing jobs in neighbouring villages where payment was in the form of in-kind share of the harvest which was larger than wage or contract work paid for in cash.

Threshing. Mechanical threshers were adopted because of their efficiency, less grain loss and immediate recovery of the threshed grain within the day compared with hand threshing which must be closely supervised by the farmer-owner to control losses and technical pilferage (not threshing thoroughly to give more yield to gleaners who are relatives of the threshing labourers). Mechanical threshing was dominated by the crewmen of the hired thresher. They performed the feeding of the harvested rice, bagging the threshed grain, sewing the bags and stacking them at the threshing site. Other men did the in-field and field-to-road transport as well as loading on the transport vehicle, consisting of animal-drawn sled or cart or motorised tricycles, trailers pulled by small tractors, jeepneys, pick-up trucks and lorries which were usually hired by the buyer of the harvested paddy. Depending upon the distance, the transport job was paid for separately from harvesting.

Gleaning. Women and children, usually the relatives of the hired labour for the threshing operation, tried to recover grains from the straw or threshing yard. Landless and marginal farmers sometimes did gleaning to augment family income. Each gleaner could recover about 25 kg of paddy in a day.

Hauling. Men usually dominated this job, which required strength and stamina. Women assisted in lifting the bag onto the shoulder or head of the men.

Drying. When sundrying the grain, men did the hauling, loading and unloading on the drying floor while the women and children took turns in spreading, stirring and watching over the grains to be dried. They also assisted the men in bagging and loading of the grains at the end of the drying period.

Storing. Most of the grains were sold immediately to the buyer. Only about 800 to 1500 kg were stored per farm household per season. Storage could be in bulk or in sacks in one corner of the house, in bamboo baskets or wooden boxes. Sometimes the grain was stored in a warehouse which could be a separate shed or an extension of the house with galvanised sheet roofing and wooden or concrete walls and floors.

Marketing. In one village, farmers sold their paddy in buying stations located outside the village from where they could obtain cash payments and loans and farm inputs. In another far-away village, buyers pick up the grains using big trucks to ensure payment from farmers who obtained loans or advanced payments from them. Both the father and the mother decided on the volume and price of the grain to be marketed but the mother usually managed and kept the proceeds after marketing.

The above observations in the post-harvest operations for rice may vary from country to country, depending upon the culture. However, in most developing countries in Asia, women do share a major portion of the labour inputs in such operations.

In the northern mountain provinces or Lao PDR where exchange of labour is still practised, especially in subsistence level farming in the slash and burn cultivation of rice, the whole handling job from harvesting to storage is done without any cash payments - only food and drinks and return labour. Women usually perform the hauling and piling of the harvested stalks to the threshing site, and the cleaning or winnowing operation. Some women participate in the actual threshing operation itself, which is predominated by men.

Custom threshing operation by engine-powered threshers is becoming popular in extensive lowland rice areas near urban centres.

In Bhutan, women haul the harvested stalks to the house and if the grain shatters due to over maturity or varietal characteristic, losses are incurred at various actions such as in lifting, carrying and laying down the harvested bundle.

In the Philippines, women had greater than 50 percent involvement in post-harvest activities, mainly in sundrying and marketing. Women were significant participants in the disposal of output, specifically in marketing decisions such as where and when to sell and what selling price. Women contributed 17 percent and 26 percent of the family labour used in harvesting of wet and dry season rice, respectively. They contributed 16 percent and 19 percent in total post-harvest activities.

Few alternative employment opportunities or rural industries existed to absorb the displaced labour at the time the machines were introduced. Caution should be exercised in introducing any labour-displacing technology such as mechanical harvesters in a labour-surplus, low-wage environment.

Decisions on which type of rice mill is to be used for milling the family grain are often made by women, especially when they are involved in backyard swine production. While increasing milling recovery of such rice mills, the reduced bran-rice mixture and brokens decreases the value of the by-product as animal feed, an important feed in backyard swine production in the Philippines.

Any intervention, which eliminates the Engleberg type rice mill or improve it to increase the milling recovery, will bring about socio-economic problems and choice of any other alternatives. Using other feed ingredients such as crop residues to reduce the rice bran requirements is a potential solution to the problem.

The decline in demand for female labour adversely affects the category of rural women at risk- those belonging to landless householders or without sufficient land to support their families. This situation aggravated further when the female is head of a household with children. With the introduction of small power threshers in the early 1980s, the time spent by women in harvesting and threshing decreased from 8 h/ha in 1975 to 3 h/ha in 1980. On the other hand, use of portable threshers decreased turn-around time for rice production and enabled farmers to grow two crops of direct seeded rice in a year.

In Bangladesh, rural women are responsible for most post-harvest operations, particularly processing which is a carried out near or on their homesteads. Rural electrification stimulated the rapid spread of small, inexpensive, electrically-driven mechanical rice mills in the early 1970s. By 1979, about 23-26 percent of total rice production was machine-milled and labour productivity was substantially higher (5.6 t/man-day) for machine milling compared to the manually operated *dheki* mill (0.2 t/man-day).

The improved mills have benefited farm families by reducing the participation of female household labour in this arduous task and by lowering the cost of hired labour. The mills also increased milled rice output and reduced processing losses. It was estimated that household labour for husking declined from 58 percent to 55 percent and hired labour from 32 percent to 16 percent.

PAGE < TOC PAGE >

INPhO e-mail: inpho@fao.org
INPhO homepage: http://www.fao.org/inpho/

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

PAGE < TOC PAGE >

Organisation: International Rice Research Institute, Philippines (IRRI)
Author: Ray Lantin
Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis (Language&Style), Carolin Bothe (HTML transfer)

CHAPTER X RICE: Post-harvest Operations

6. References

Acasio, U.A. and Maxon, R.C. (1990). Bulk handling and storage of grains: A Pakistan experience. *Proceedings of the 13th ASEAN Seminar* *on Grain Postharvest Technology*. pp. 349-369. Naewbanij, J.O., ed. ASEAN Grain Postharvest Programme. Bangkok, Thailand.

Anchiboy, T.F. and Manalabe, R.E. (1996). Design and development of a rotary semi-fluidized system dryer for paddy. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995*. ACIAR Proceedings No. 71. pp. 245-249. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

Andales, S.C. (1984). Paddy and rice storage. *Consultants' Report on ADB Project on Storage in Burma (ADB Loan No. 509 BUR (SF)*. Asian Development Bank, Manila, Philippines.

Andales, S.C., Alvarez, E.L. and Tec Jr., A.B. (1980). *Terminal report of the UPLB- IDRC project (Phase I) on rice post-production technology*. Institute of Agricultural Engineering and Technology (INSAET), UPLB, College, Laguna, Philippines.

Andales, S.C. (1996). Problems and priorities of grain drying in the Philippines. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995.* ACIAR Proceedings No. 71. pp. 46-53. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR, Canberra, Australia.

Araullo, E.V., de Padua, D.B. and Graham, M. (1976). *Rice Post-harvest Technology*. IDRC. Ottawa, Canada.

Arboleda, J.R. (1975). Improvements of the *kiskisan* rice mill. *Proceedings of IRRI Saturday Seminar*. Agricultural Engineering Department. International Rice Research Institute (IRRI). Los Baños, Laguna, Philippines.

Asian Development Bank. (1983). *Appraisal of food grain storage in the Islamic Republic of Pakistan*. Manila, Philippines.

Bakshi, A.S. and Singh, R.P. (1979). Drying of high moisture parboiled rice. *Proceedings of the 1979 summer meeting of the ASAE, Winnipeg, Manitoba, Canada.*

Baloch, U.M. and Khan, M.F.U. (1990). *Rice by-product utilisation in selected countries in Asia*. Regnet.

Ban, Le Van, Bui Ngoc Hung and Phan Hieu Hien. (1996). A low-cost in-store dryer for small farmers. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995*. ACIAR Proceedings No. 71. pp. 308-313. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

Banks, H.J. (1987). Research and development opportunities for fumigation in the ASEAN region as a component of integrated commodity management. *Grain Postharvest Systems*. *Proceedings of the 10th ASEAN Technical Seminar on Grains Postharvest Technology*. de

Mesa, B.M., ed. ASEAN Grain Postharvest Programme. Bangkok, Thailand.

Basunia, Mohammad Ali, Takemi Abe, and Yoshio Hikida. (1997). A comparative study of the quality of rough rice stored in bamboo, wooden and metal bins. *Agricultural Mechanisation in Asia, Africa and Latin America*. Vol. 28, No. 2. pp. 41-47, 52.

Bulaong, M.C. (1996). Commercialisation of a mobile flash dryer for farmers cooperatives. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995.* ACIAR Proceedings No. 71. pp. 332-225. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

Caliboso, F.M., Sayaboc, P.D. and Amoranto, M.R. (1985). Pest problems and use of pesticides in grain storage in the Philippines. *Proceedings of an International Conference on Pesticides and Humid*

Tropical Grain Storage Systems held in Manila, Philippines. ACIAR Proceedings No. 14. ACIAR. Canberra, Australia.

Calpatura, R.B. (1978). Variety maturity and length of straw cutting interaction in the grain losses of rice during harvesting. *Report on project conducted in cooperation with the National Food Authority Region I Office*. Isabela State University, Echague, Isabela, Philippines.

Castillo, G.T. (1985). Research programme proposal on Women in Rice Farming Systems (WIRFS). International Rice Research Institute (IRRI). Los Baños, Philippines.

Chung, Chang Joo, Kwan Hee Ryu, Jung Geol Park and Seong Beom Lee. (1981). Operational factors affecting milling performance of a rice whitener. *Proceedings of the 4th Annual Workshop On Grains Post Harvest Technology*. Southeast Asia Cooperative Postharvest Research and Development Programme (SEARCA). SEARCA College, Laguna, Philippines.

Courtois, F. (1996). Non-conventional grain drying technology. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995.* ACIAR Proceedings No. 71. pp. 229-235. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

Dash, S.K., Mohanty, S.N. and Sahoo, T.B. (1997). Rice postharvest practices in Orissa, India. *Agricultural Mechanisation in Asia, Africa and Latin America*. Vol. 28, No. 2. pp. 30-36, 40.

De Padua, D. (1996). Perspectives on drying problems in the Southeast Asian Region and results of R & D projects to solve them. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995*. ACIAR Proceedings No. 71. pp. 67-73. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

Dommershuijzen, J.J. and Lozare, J.V. (1990). Rice by-product utilisation in selected South and East Asian countries. *Proceedings of the 13th ASEAN Seminar on Grain Postharvest Technology*. pp. 417-442. Naewbanij, J.O., ed. ASEAN Grain Postharvest Programme. Bangkok, Thailand.

Duff, B. and Estioko, I. (1972). Establishing design criteria for improved rice milling technologies. *Proceedings of Saturday Seminar 16 August 1972.* Agricultural Engineering Department. International Rice Research Institute (IRRI). Los Baños, Laguna, Philippines.

Efferson J.N. (1985). Rice Quality in World Markets. *Proceedings of the international Rice Research Conference 1-5 June 1995*.

ESN and FAO. (1994). Rice in human nutrition. *Proceedings of the Eighteenth Session of the International Rice commission 5-9 September 1994*. Rome, Italy.

Fa, Loo Kau. (1996). The development of artificial drying of paddy in Malaysia. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995*. ACIAR Proceedings No. 71. pp. 316-320. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

FAO. (1987). Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

FAO RAPA. (1991). Rice husk gasification technology in Asia. *RAPA Publication 1991/2*. FAO Regional Office for Asia and the Pacific. Maliwan Mansion, 39 Phra Atit Road, Bangkok 10200, Thailand.

FAO, UNDP and Department of Food, Ministry of Food and Civil Supplies (India). (1986). Warehouse management of bag storage of grains. *Proceedings of Regional workshop on warehouse management of bag storage of grains.* New Delhi, India.

FAO. (1979). Rice processing machines. *Agricultural Services Bulletin 37.* Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

FAO. (1980). Consultant report on promotion of low cost and effective technology suitable for use by small farmers in Bangladesh, Nepal and the Philippines. *No. RAPA 42*. Bangkok, Thailand.

FAO. (1982). China: Grain Storage Structures. *Agricultural Services Bulletin 49*. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

FAO. (1982). China: Post-harvest grain technology. *Agricultural Services Bulletin 50.* Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

FAO. (1982). Aeration of grain in subtropical climates. *Agricultural Services Bulletin 51*. Food and Agriculture Organization of the United

Nations (FAO). Rome, Italy.

FAO. (1983). Processing and storage of food grains by rural families. *Agricultural Services Bulletin 53*. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

FAO. (1985). Manual of pest control for food security reserve grain stocks. *Plant Production and Protection Paper 73*. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

FAO. (1985). Rice processing industries. *Proceedings of Regional workshop on rice processing industries*. *15-20 July 1985*. Jakarta, Indonesia.

FAO. (1995). *Agrostat 95: FAO Statistical Yearbook*. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

Gariboldi, F. (1974). Rice milling equipment operation and maintenance.

Agricultural Services Bulletin 22. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

GASGA. (1989). Research and development issues in grain postharvest problems in Asia. *Proceedings of GASGA Executive Seminar No. 2, 31 August 1988.* Group for Assistance on Systems Relating to Grain After Harvest. Canberra, Australia.

Girish, G.K. and Kumar, A. (Editors). (1990). *Proceedings of Regional workshop on warehouse management of stored food grains*. Department of Food, Ministry of Food and Civil Supplies (India). FAO. UNDP. New Delhi, India.

Henderson, S.M. and Perry, R.L. (1966). *Agricultural process engineering.* University of California. Davis, California, USA.

Hollingdale, A.C. (1996). Renewable energy sources for grain drying. *Proceedings of an International Conference on Grain Drying in Asia.*

FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995. ACIAR Proceedings No. 71. pp. 220. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

Houjin, Li. (1996). The present situation and directions for development of grain drying in China. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995.* ACIAR Proceedings No. 71. pp. 314-315. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

Houston, D.F. (1972). *Rice chemistry and technology*. American Association of Cereal Chemists, Inc. St. Paul, Minnesota, USA.

Iamsuri, Kamchai. (1992). Rice processing and marketing in Thailand. State of the Art of the Grain Industry in the ASEAN: A Focus on Grain Handling and Processing. *Proceedings of the 15th ASEAN Seminar on*

Grain Postharvest Technology, Singapore, 8-11 September 1992. pp. 74-77. Naewbanji, J.O., ed. ASEAN Grain Postharvest Programme. Bangkok, Thailand.

IRRI. (1997). *IRRI rice facts*. The International Rice Research Institute (IRRI). Los Baños, Philippines.

Itani, T. and Fushimi,T. (1996). Influence of pre-and post-harvest conditions on 2 acetyl-1-pyrroline concentration in aromatic rice. *Proceedings of the 2nd Asian Crop Science Conference, Fukui, Japan, 21-23 August 1995.*

Juliano B.O. and Perez C.M. (1990). Grain quality characteristic of export rice in selected markets. *Cereal Chem*. (67) 21: 192-197.

Juliano, B.O. (1985). Rice hull and rice straw. *Rice Chemistry and Technology, 2d ed.* American Association of Cereal Chemists. St. Paul, Minnesota, USA.

Juliano, B.O. and Villareal, C.P. (1993). *Grain quality evaluation of world rice*. International Rice Research Institute (IRRI). Los Baños, Philippines.

Juliano, B.O. and Hicks, P.A. (1990). Utilisation of rice functional properties to produce rice food products with modern processing technologies. *Proceedings of the 17th session of the International Rice Commission, Goiania, Brazil*.

Juliano, B.O. and Perez, C.M. Critical moisture content for fissures in rough rice. *Cereal Chemistry*, (70): 613-615.

Juliano, B.O. (1996). Grain quality problems in Asia. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995.* ACIAR Proceedings No. 71. pp. 15-22. Champ,B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

Kunze, O.R. (1996). Effect of drying on grain quality. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995.* ACIAR Proceedings No. 71. pp. 178. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

Kunze, O.R. (1996). Effect of environment and variety on milling qualities of rice. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995*. ACIAR Proceedings No. 71. pp. 220. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

Lal, S. and Ramam, C.P. (1996). Grain drying in India - problems and prospects. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995.* ACIAR Proceedings No. 71. pp. 294-301.

Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

Lantin, R. M., Bernabe L.P. and Manalingod, H.T. (1996). Revisiting sun drying: Widely adopted but technologically neglected. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995.* ACIAR Proceedings No. 71. pp. 302-307. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR, Canberra, Australia..

Lindner, R.K. (1986). Adoption and diffusion of technology: an overview. *Proceedings on Technology Change In Postharvest Handling and Transportation of Grains in the Humid Tropics*. ACIAR Proceedings No. 19. ACIAR. Canberra, Australia.

Maxon, R.C. (1989). Insect resistance, the next wheat crisis. *The Econogram.* Economic Analysis Network, Ministry of Food and Agriculture. Islamabad, Pakistan.

Maxon, R.C. (1988). Impact of the fair average quality procurement procedure and no loss policy on public sector storage of wheat. *Storage Technology Development and Transfer Project Report No. 3*. Food and Feed Grain Institute. Kansas State University, Manhattan, Kansas, USA.

Mazaud, F. (1996). Mechanical drying - horizon 2010: an increased role predicted. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995.* ACIAR Proceedings No. 71. pp. 323-331. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

Mendoza, Ma. E., Rigor, A.C. and Abit, F.L. (1981). Grain quality deterioration in on farm level of operation. *Proceedings of the 4th Annual Workshop of Grains Postharvest Technology*. SEARCA College, Laguna, Philippines.

Mondal, K.M.S.H. and Malik, M.A. (1996). Traditional paddy drying in Bangladesh and associated problems. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995*. ACIAR Proceedings No. 71. pp. 332-335. Champ, B.R., Highley, E. and Johnson, G.I., eds. ACIAR. Canberra, Australia.

NAPHIRE. (1997). *Technical Guide on Grain Postharvest Operation*. National Postharvest Institute for Research and Extension (NAPHIRE). Munoz, Nueva Ecija, Philippines.

NFA. (1988). Harvesting, threshing and cleaning of paddy. *Report on the JICA (Japan International Cooperation Agency) Postharvest Facility Assistance Program*. National Food Authority (NFA), Quezon City, Philippines.

NRI. (1991). Postharvest discolouration of cereal grains. *Report on operational Programmes:1989-91*. pp 256-258. Natural Resources

Institute (NRI). Chatham Maritime, Chatham, Kent, UK.

Oerke, E.C., Dehne, H.W., Schonbeck, F. and Weber, A. (1994). *Crop production and protection estimated losses in major food and cash crops*. pp. 89-163. Elsevier Science B.V. Amsterdam, The Netherlands.

Ong, S.H. (1992). Recent developments in grain protectants. *Proceedings of the 15th ASEAN Seminar on Grain Postharvest Technology, State of the Art of Grain Industry in the ASEAN: A Focus on Grain Handling and Processing held in Singapore, 8-11 September 1992*. pp. 288-297. Naewbanij, J.O., ed. ASEAN Grain Postharvest Programme. Bangkok, Thailand.

Paras, A.S. Jr. (1975). *Rice milling principle and systems*. Institute of Agricultural Engineering. University of the Philippines. Los Baños, SEARCA College, Laguna, Philippines.

Paris, T.R. and Duff, B. (1989). Technology bias in rice postharvest systems in the Philippines: evaluating the needs of women and children. *Rural Household Members in Rice Postproduction Systems*. International Rice Research Institute (IRRI). Los Baños, Philippines.

Paz, R.R. and Cabacungan, R. (1986). Paddy loss assessment and reduction on farm operations. *Proceedings of the 9th ASEAN Technical Seminar on Grain Postharvest Technology*. pp. 286-302. de Mesa, B., ed. ACPHP. Manila, Philippines.

PCARRD. (1987). The Philippines recommendations for rice postproduction operations. *PCARRD Technical Bulletin Series No. 63*. Philippine Council for Agriculture, Forestry and Natural Resources Research and Development. Laguna. National Postharvest Institute for Research and Extension, Muñoz, Nueva Ecija, Philippines.

Phongsupasamit, S. (1981). Grain quality improvement through solar system in double cropping of rice. *Proceedings of the 4th annual* *workshop on grains post-harvest technology*. SEARCA College. Laguna, Philippines.

Quereshi, S.A. (1989). Grain storage in Pakistan. *Proceedings of lecture at the Master Trainers Course, Storage Technology Development and Transfer Project.* Lahore, Pakistan.

Rahim Muda and Ong, S.H. (1992). Integrated use of pesticides in grain storage in the humid tropics. A completion report on ACIAR Project No. 8309/8311 and 8609. *Reference Guide On Grains Postharvest.* Muñoz, Nueva Ecija, Philippines.

Ren-Yong, Chi, Zhuge Gen-Zhang, and Wan Shan-Yang. (1990). Loss assessments and factor-finding analysis of grain post-production systems in China. *Proceedings of the 13th ASEAN Seminar on Grain Postharvest Technology, Brunei Darussalam, 4-7 September 1990.* pp. 370-392. Naewbanij, J.O., ed. ASEAN Grain Postharvest Programme. Bangkok, Thailand.

Ruiten, H.V. (1980). Operation and maintenance manual for the rice milling training laboratory. *Training of technicians for grain industries*. FAO/UNDP/NFAC SF PHI-70/584 project. University of the Philippines Los Baños, SEARCA College, Laguna, Philippines.

Samson, B. and Duff, B. (1973). Patterns and magnitudes of grain losses in paddy production. *Proceedings of IRRI Saturday Seminar. July 1973.* International Rice Research Institute (IRRI). Los Baños, Philippines.

Sayaboc, P.D., Acda, M.A.,. Gibe, A.J.G., Gragasin, C.B. and Villanueva, R.R. (1990). Bag stack spraying and fumigation of milled rice. *Proceedings of the 13th ASEAN Seminar on Grain Postharvest Technology, Brunei Darussalam, 4-7 September 1990.* pp 445-456. Naewbanij, J.O., ed. ASEAN Grain Postharvest Programme. Bangkok, Thailand.

Semple, R.L. (1986). *Insect pests of stored grain and their control*. ASEAN Crops Postharvest Programme. Bangkok, Thailand.

Semple, R.L., Hicks, P.A., Lozare, J.V. and Castermans, A. (Editor-Compilers) (1988). Grain storage systems in selected Asian countries. *Proceedings of the workshops/study tour of grain storage systems*. Zheijang Province, People's Republic of China. Regional Association of Post-Harvest Technology Networks in Asia (REAPASIA). People's Republic of China.

Semple, R.L. (1990). Post-harvest technology storage development and application in developing Asian Countries. *Proceedings of Regional workshop on warehouse management of stored food grains*. New Delhi, India.

Singhagajen, S and Thongswang, M. (1981). Small-scale rice milling at the village level: Results of a survey in Thailand. *Proceedings of the 4th annual workshop on grains post harvest technology*. Southeast Asia Cooperative Post-harvest Research and Development Programme, Southeast Asia Regional Centre for Agriculture and Graduate Studies

(SEARCA). SEARCA College, Laguna, Philippines.

Sison, W.M., Sarmiento Jr., R.C. and Magno Jr., E.A. (1981). Performance test of the prototype steel-stone milling roller for the Engleberg rice mill. *Proceedings of the 4th annual workshop on grains post harvest technology*. Southeast Asia Cooperative post-harvest Research and Development Programme. SEARCA College, Laguna, Philippines.

Snelson, J.T. (1985). Regulatory requirements for pesticide use. *Proceedings of Pesticides and humid tropical grain storage systems*. ACIAR Proceedings No. 14. pp. 106. Champ, B.R.and Highley, E., eds.

Teter, N. (1987). Paddy drying manual. *Agricultural Services Bulletin 70.* FAO. Rome, Italy.

Toquero, Z. F. and del Mundo, A.M. (1990). Women in postproduction systems. *Proceedings of the 13th ASEAN Seminar on Grain Postharvest*

Technology, Brunei Darussalam, 4-7 September 1990. pp 395-413. Naewbanij, J.O., ed. ASEAN Grain Postharvest Programme. Bangkok, Thailand.

Toquero, Z.F. and Duff, B. (1974). Survey of postproduction practices among rice farmers in Central Luzon. Proceedings of Saturday Seminar Paper. International Rice Research Institute (IRRI). Los Baños, Philippines.

Toquero, Z.F. and Duff, B. (1985). Physical losses and quality deterioration in rice postproduction systems. *IRRI Research Paper Series No. 107.* International Rice Research Institute (IRRI). Los Baños, Philippines.

Tumambing, J.A. (1995). Small-scale grain dryers. *Proceedings of an International Conference on Grain Drying in Asia. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995.* ACIAR Proceedings No. 71. Champ, B.R., Highley, E. and

Johnson, G.I., eds. ACIAR. Canberra, Australia.

U Aye. (1980). Consultant's report on promotion of low-cost and effective technology suitable for use by small farmers in Bangladesh, Nepal and the Philippines. *FAO No. RAPA 42*. Bangkok, Thailand.

USDA. (1980). Rice post-harvest losses in the developing countries. *Science and Educational Administration. Agricultural Reviews and Manual*. United States Department of Agriculture (USDA).

Unnevehr, L.J., Duff, B. and Juliano, B.O. Consumer demand for rice grain quality introduction to major findings. *Rice Policies in Southeast Asia Project*. A joint project of IFRI, IRRI and IFDC. International Rice Research Institute (IRRI). Los Baños, Philippines.

Van Ruiten, H.Th.L. (1981). Milling performance of single pass rice mill units using one abrasive roll and one rubber roll instead of two-rubber rolls. *Proceedings of the 4th annual workshop on grains post harvest* *technology*. Southeast Asia Cooperative Post harvest Research and Development Programme. SEARCA College, Laguna, Philippines.

Wimberly, J.E. (1983). *Technical Handbook for Paddy Postharvest Industry in Developing Countries*. International Rice Research Institute (IRRI). Los Baños, Laguna, Philippines.

Worthing, C.R. and Walker, S.B. (Editors) (1987). *Pesticide Manual, 8th Edition*. The British Crop Protection Council.

Xuan, Nguyen Van, Truong Vinh, Pham Tuan Anh, and Phan Hieu Hien. (1995). Development of rice-husk furnaces for grain drying. *Proceedings of an International Conference on Grain Drying in Asia*. *FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, 17-20 October 1995.* ACIAR Proceedings No. 71. pp. 336-341. Champ, B.R., Highley, E. and Johnson, G.I.., eds. ACIAR. Canberra, Australia.

Yap, Chan Ling. (1992). World rice and maize markets in 1992 and prospects towards the year 2000. *Proceedings of the 15th ASEAN Seminar on Grain Postharvest Technology, State of the Art of the Grain Industry in the ASEAN: A Focus on Grain Handling and Processing held in Singapore, 8-11 September 1992*. pp 3-25. Naewbanij, J.O., ed. ASEAN Grain Postharvest Programme. Bangkok, Thailand.

Yong, He, Bao Yidan, Liu Xiansheng, and Algader, A.H. (1997). Grain postproduction practices and loss estimates in South China. *Agricultural Mechanisation in Asia, Africa and Latin America, Vol. 28, No. 2*. pp. 37-40.

6.1 Additional references.

Alam, A. and Sekhon, K.S. (1990). Postharvest technology for farm women. *Women in Agriculture - Technology Perspective*. Prasad, C. and Shri Ram, eds. International Federation for Women in Agriculture (IFWA). Krishi Anusandhan Bhawan (ICAR), Dr. K. S. Krishnan Marg, New Delhi-110 012, India.

Bansal, H.D. (1986). Food grain storage organisation in India. *Proceedings of the Regional workshop on Warehouse Management of Bag Storage of Grain, held in New Delhi, India, 8-17 September 1986*. FAO, UNDP and the Department of Food, Ministry of Food and Civil Supplies, India.

Kushwaha, K.S., Sharma, U.S. and Bina Srivastava. (1990). Postharvest and allied agricultural technologies for farm women - a case study. *Women in Agriculture - Technology Perspective.* Prasad, C. and Shri Ram, eds. International Federation for Women in Agriculture (IFWA), Krishi Anusandhan Bhawan (ICAR), Dr. K. S. Krishnan Marg, New Delhi-110 012, India.

Mittra, B., Lahiri, N.D. and Mahaptra, S.C. (1990). Women in rice-based farming system - a case study. *Women in Agriculture - Technology Perspective*. Prasad, C. and Shri Ram, eds. International Federation for

Women in Agriculture (IFWA), Krishi Anusandhan Bhawan (ICAR), Dr. K. S. Krishnan Marg, New Delhi-110 012, India.

Nyanteng, V.K. (1990). Women in West African Rice production systems - issues for research and development. *Women in Agriculture - Technology Perspective.* Prasad, C. and Shri Ram, eds. International Federation for Women in Agriculture (IFWA), Krishi Anusandhan Bhawan (ICAR), Dr. K. S. Krishnan Marg, New Delhi-110 012, India.

Res, L. (1983). Changing labour allocation patterns of women in rice farm households: a rainfed rice village, Iloilo Province, Philippines. *Proceedings of a conference on Women in Rice Farming Systems. Women in Rice Farming.* International Rice Research Institute (IRRI). Los Baños, Philippines. Grower Publishing Company, Limited, Grower House, Croft Road, Aldershot, Hants GU11 3HR, England, UK.

Sayaboc, P.D., Gibe, A., Villanueva, R., Prudente, A., Acda, M. and

Gragasin, C. (1996). Increasing efficacy of integrated pest control in grain storage and minimising pesticide residues by use of mixtures of grain protectants. *ACIAR Project Terminal Report*. NAPHIRE, Munoz, Nueva Ecija, Philippines.

Swaminathan, M.S. (1990). Imparting a rural women user's perspective to agricultural research and development. *Women in Agriculture - Technology Perspective*. Prasad, C. and Shri Ram, eds. International Federation for Women in Agriculture (IFWA), Krishi Anusandhan Bhawan (ICAR), Dr. K. S. Krishnan Marg, New Delhi-110 012, India.

Unnevehr, L.J. and Stanford, M.L. (1993). Technology and the demand for women's labour in Asian rice farming. *Proceedings of a conference on Women in Rice Farming Systems. Women in Rice Farming*. International Rice resrach Institute (IRRI). Los Baños, Philippines. Grower Publishing Company, Limited, Grower House, Croft Road, Aldershot, Hants GU11 3HR, England, UK.

White, B. (1983). Women and the modernisation of rice agriculture: some general issues and a Javanese case study. ***Proceedings of a conference on Women in Rice Farming Systems. Women in Rice Farming.*** International Rice Resarch Institute (IRRI). Los Baños, Philippines. Grower Publishing Company, Limited, Grower House, Croft Road, Aldershot, Hants GU11 3HR, England, UK.

PAGE < TOC PAGE >

INPhO e-mail: inpho@fao.org
INPhO homepage: http://www.fao.org/inpho/

Home"" """""> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

PAGE < TOC PAGE >

Organisation: Instituto de Desarrollo Agroindustrial (INDDA)
Author: Magno Meyhuay

Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis (Language&Style), Carolin Bothe (HTML transfer)

CHAPTER XI QUINUA: Post-harvest Operations

---

1 Introducción

La quinua (*Chenopodium quinoa Wild*) se cultiva en zonas áridas y semiáridas de los Andes. Tiene una gran adaptabilidad, tanto en latitud como en altitud, encontrándose en el Perú desde Tacna hasta Piura, y desde el nivel del mar hasta los 4 000 metros de altura.

Por sus características nutricionales, contenido de proteínas, vitaminas y minerales, constituye una de las bases en la alimentación del poblador altoandino.

Posee una proteína de alto valor biológico. Por su elevado contenido de lisina y su balance de aminoácidos esenciales, resulta comparable a la proteína de origen animal.

Se usa ampliamente, tanto en la alimentación humana, como animal, empleándose las hojas y tallos tiernos como verdura de hojas, hasta la fase del inicio del panojamiento, luego se consumen las panojas tiernas en reemplazo de verduras de inflorescencia, y el grano maduro, directamente o procesado.

Industrialmente se obtienen los siguientes productos: quinua perlada, hojuela de quinua, quinua precocida, quinua instantánea, fideos, sémola, galletas, expandido, etc.

Esta planta presenta una gran variabilidad y diversidad de formas. Se pueden clasificar sus variedades o ecotipos en 5 categorías básicas, según su adaptación a las características geográficas: quinuas del valle, quinuas del altiplano, quinuas de terrenos salinos, quinuas del nivel del mar y quinuas subtropicales. En el cuadro 1, se muestra las principales variedades de quinua que se cultivan en el Perú, y en el cuadro 2, la disponibilidad de semilla según las Estaciones Experimentales, siendo las principales en orden de importancia las variedades Hualhuas, Mantaro, Blanca de Junín y Salcedo INIA.

Según el estudio de demanda de quinua, elaborado por el convenio ADEX/USAID/MSP/COSUDE para el año 1 996, el consumo percápita estimado en el

Perú fue de 0,517 kg con tendencia a ir incrementándose en los próximos años. Esto se logrará presentándole al consumidor una serie de alternativas a base de quinua y además haciéndole conocer las bondades nutricionales del producto.

Cuadro 1: Principales variedades de quinua

Variedades o ecotipos	Altitud msnm	Color de grano	Sabor	Periodo vegetativo
Blanca Junín	1 500-3 500	Blanco	Dulce	160-180
Rosada Junín	2 000-3 500	Blanco	Dulce	160-180
Nariño Amarillo	800-2 500	Blanco	Dulce	180-200
Marangani	800-3 500	Amarillo	Amarga	60-180
Quillahuaman INIA	800-3 500	Blanco	Semidulce	160-180
Tahuaco i	1 500-3 900	Blanco	Semidulce	150
Kancolla	800-4 000	Blanco	Dulce	140-160
Cheweca	1 500-3 500	Amarillo	Dulce	150-180
Chucapaca	800-3 900	Blanco	Semidulce	150-160
Kamiri	800-4 000	Blanco	Semidulce	150-160

Camacan II	800-4 000	Blanco	Semidulce	150-160
Rosada Cusco	800-3 500	Blanco	Semidulce	160-180
Real	500-4 000	Blanco	Semidulce	110-130
Boliviana Jujuy	500-3 500	Blanco	Semidulce	100-120
Sajama	> 3 500	Blanco	Dulce	150-170
Blanca de Juli	---	Blanco	Semidulce	150-180
Mantaro	1 500-3 500	Blanco	Semidulce	---
Hualhas	1 500-3 500	Blanco	Semidulce	---
Salcedo INIA	---	---	---	---

FUENTE: Ministerio de Agricultura - Instituto Nacional de Investigación Agraria - Programa Nacional de Investigación de Cultivos Andinos. Junio - 1997.

Cuadro 2. Disponibilidad de semilla de quinua en el Perú según estaciones experimentales año 1 997.

Estación Experimental	Cultivar	Categoría	Disponibilidad (kg)
EE. Santa Ana -	Mantaro	Básica	5 000

Huancayo		Registrada	1 430
	Huancayo	Básica	380
	Hualhuas	Básica	2 900
		Certificada	10 020
		Registrada	1 500
EE Illpa-Puno	Sajama	Básica	90
	Blanco de Juli	Básica	135
	Kancolla	Básica	29
	Tahuaco I	Básica	497
	Kamiri	Básica	07
	Cheweca	Básica	16
	Chucapaca	Básica	22
	Salcedo INIA	Básica	938
EE Andes-Cusco	Blanca Junín	Básica	2 225
	Kancolla	Registrada	219
	Cheweka	Registrada	265
EE. Baños del Inca	Amarillo Marangani	S/I	S/I
	Nariño	S/I	S/I

	Blanca de Junín	S/I	S/I
EE. Canaan - Ayacucho	Ayacuchano	S/I	S/I
	Blanca de Junín	S/I	S/I

FUENTE: Instituto Nacional de Investigación Agraria - 1 997.

S/I : Sin información.

INPhO e-mail: inpho@fao.org
INPhO homepage: http://www.fao.org/inpho/

Organisation: Instituto de Desarrollo Agroindustrial (INDDA)
Author: Magno Meyhuay
Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis

(Language&Style), Carolin Bothe (HTML transfer)

CHAPTER XI QUINUA: Post-harvest Operations

---

2 Producción, importación-exportación

2.1 Perú: Producción Nacional

En los últimos años (1 994-1 997) la producción anual de quinua ha fluctuado entre 14 000 a 24 000 TM y la superficie cosechada entre 19 000 a 26 000 Has. En el año 1

997 se observa un incremento en la producción y área cosechada, respectivamen-te (Ver cuadros 3 y 4), debido al casi obligatorio uso de la quinua como un insumo en el programa de desayunos escolares (sólidos y líquidos).

El rendimiento nacional se mantuvo entre 700 a 800 kg/Ha en promedio, tal como se muestra en el cuadro 5, alcanzándose los mejores rendimientos en la región Arequipa.

Los mayores productores de quinua a nivel de la región en orden de importancia son: José Carlos Mariátegui, Andrés Avelino Cáceres e Inca, concentrando entre las tres alrededor del 90% de la producción nacional (Ver cuadro 6).

En el cuadro 7 se presenta la producción de quinua por mes, para los años 1 995 - 1 996, del cual se desprende que los meses de mayor producción son entre abril y junio (Ver gráfico 1).

Cuadro 3. Perú: Producción de quinua a nivel nacional y por regiones 1992-1997. (TM)

Regiones	1 994	1 995	1 996	1 997

Nor Oriental	82	120	142	105
La Libertad	93	237	253	274
Chavín	267	357	642	456
Lima	5	32	3	0
Libertadores Wari	872	1 137	1 185	1 268
Arequipa	169	129	164	156
José Carlos Mariátegui	11 744	8 364	4 756	14 191
Inca	1 129	1 245	797	3 897
Andrés A. Cáceres	2 267	2 152	3 128	2 881
TOTAL	16 128	13 773	16 070	23 228

FUENTE: Ministerio de Agricultura: Estadística Agraria - años 1 994 - 1 997 (Setiembre).

Cuadro 4 : Superficie cosechada de quinua a nivel nacional y según regiones (Has).

Región	1 994	1 995	1 996
Nor Oriental	130	154	162
La Libertad	118	277	346

La Libertad	[illegible]	[illegible]	[illegible]
Chavin	320	385	612
Lima	4	27	2
Libertadores - Wari	1 270	1 521	1 581
Arequipa	120	103	120
José Carlos Mariátegui	15 380	12 555	11 708
INCA	1 204	1 275	870
Andrés A. Cáceres	2 151	2 432	3 343
NACIONAL	20 697	18 729	26 124

FUENTE: Ministerio de Agricultura - OIA: Producción Agrícola 1 994 - 1 996.

Cuadro 5. Perú: Rendimiento promedio de quinua a nivel nacional y por regiones 1 994 - 1 997 (TM/Ha)

Regiones	1 994	1 995	1 996	1 997
Nor Oriental	631	779	877	680
La Libertad	788	856	827	793
Chavín	834	927	1 052	976

Lima	1 250	1 185	1 500	-
Libertadores Wari	687	748	750	671
Arequipa	1 408	1 252	1 367	1 430
José Carlos Mariátegui	764	666	833	824
Inca	938	976	916	1 230
Andrés A. Cáceres	1 054	885	936	1 008
NACIONAL	803	735	859	S/I

FUENTE: Ministerio de Agricultura: Estadística Agraria. Años 1 994 - 1 996 y 1 997 (Setiembre).

S/I: Sin información.

Cuadro 6. Perú: Producción a nivel nacional de quinua y por principales regiones. Años 1 994 - 1 997 (TM).

Regiones	1 994	1 995	1 996	1 997*
José Carlos Mariátegui	11 744	8 364	9 756	14 191
Andrés A. Cáceres	2 267	2 152	3 128	2 881

INCA	1 129	1 245	797	3 897
Libertadores-Wari	872	1 137	1 185	1 268
Otros 1>	617	475	1 204	991
Nacional	16 629	13 373	16 070	23 228

FUENTE: Ministerio De Agricultura - OIA "Producción Agraria". Años 1 994 - 1 997.

** Proyectado*

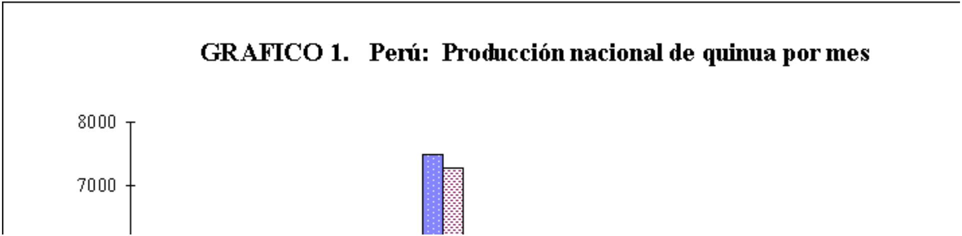
1> Nor Oriental, La Libertad, Lima, Arequipa

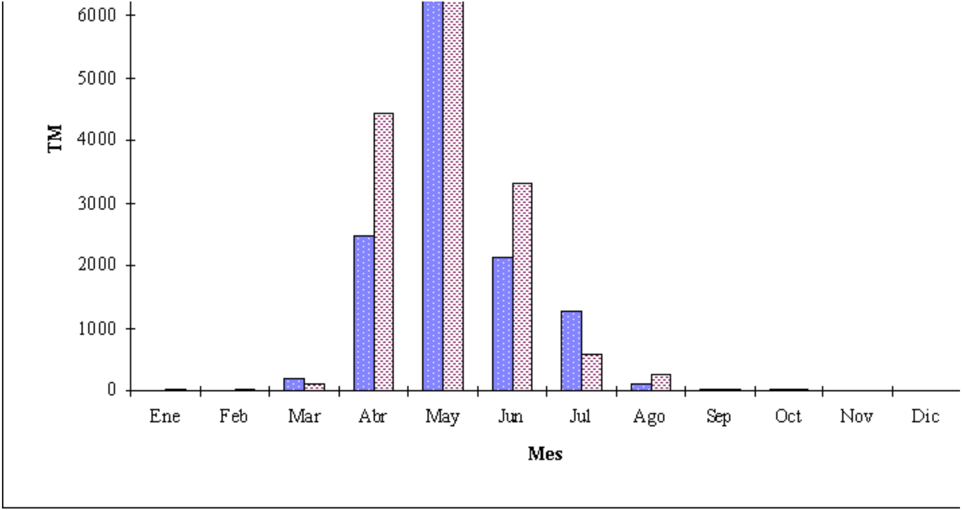
Cuadro 7 Perú: Producción nacional de quinua por mes, 1 995- 1 996 (T.M.)

	Años	
Meses	**1 995**	**1996**
Enero	0	36
Febrero	6	20
Marzo	200	112
Abril	2 484	4 417

Mayo	7 494	7 270
Junio	2 123	3 302
Julio	1 288	599
Agosto	117	260
Setiembre	27	18
Octubre	27	20
Noviembre	0	6
Diciembre	0	10
TOTAL	**13 773**	**16 070**

FUENTE: Ministerio de Agricultura - OIA "Estadística Agroindustrial". Año 1 995 - 1 996.





2.2 Perú: Exportación

Entre los años 1 993 - 1 996, el volumen de exportaciones ha experimentado un franco crecimiento. De 45 300 kg que se exportó en el año 1 993 se ha incrementado a 181 400 kg en 1 996 o en términos de Precio FOB, de $ 65 000 a $ 250 600 dólares, respectivamente.

Los principales importadores de la quinua peruana en el año 1996 en orden de importancia fueron: Japón que representó el 42% de las exportaciones totales, Estados Unidos con el 24%, Alemania con el 16% y Canadá con el 18%. Cabe resaltar que los mercados alemán y canadiense, abiertos recientemente, avizoran un enorme potencial (Ver cuadro 8).

En el cuadro 9 y gráfico 2, se aprecian las exportaciones mes a mes de quinua en el año 1 996, siendo los meses de abril y diciembre los de mayor cuantía.

Cuadro 8 : Perú: Exportación de quinua, según país de destino: 1993 - 1996.

	Cantidad (kg)				Valor FOB (en US $)			
País	1 993	1 994	1 995	1 996	1 993	1 994	1 995	1 996
Argentina	3 050	---	---	---	3 000	---	---	---
Ecuador	---	---	20 000	---	---	---	4 000	---
Francia	6	150	---	800	2	184	---	800

EE. UU.	37 154	24 830	40 985	43 000	52 894	33 747	29 848	59 100
Venezuela	---	---	152	---	---	---	144	---
Japón	5 042	22 157	---	76 300	9071	35 620	---	112 700
Alemania	48	---	---	28 200	33	---	---	38 700
Austria	---	2 000	---	---	---	1 000	---	---
Canadá	---	---	---	33 100	---	---	---	39 300
Total	45 300	49 137	61 137	181 400	65 000	70 551	33 992	250 600

FUENTE: Superintendencia Nacional de Aduanas. Ministerio de Agricultura - Oficina de Información Agraria.

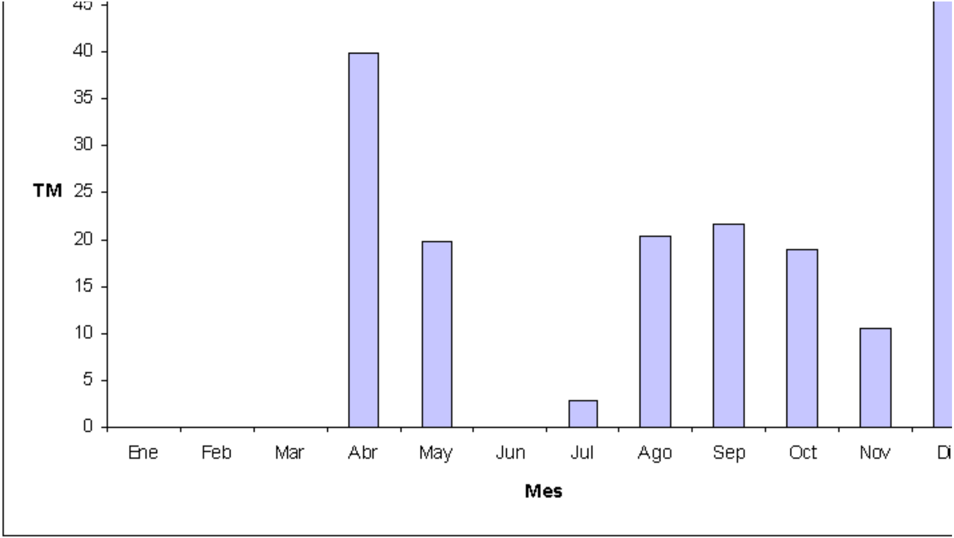
Cuadro 9 Perú: Exportación de quinua, según mes, 1996. Partida arancelaria Nandina: 1008901000

Mes	Cantidad(TM)	Valor FOB (miles US $)	precio FOB (US $/Tm)
Enero	0	0	0

Febrero	0	0	0
Marzo	0	0	0
Abril	39,9	61,8	1 548,8
Mayo	19,7	27,0	1 369,2
Junio	0	0	0
Julio	2,9	4,5	1 567,0
Agosto	20,2	21,7	1 071,6
Setiembre	21,7	29,5	1 357,9
Octubre	18,8	26,0	1 386,3
Noviembre	10,5	14,5	1 383,7
Diciembre	47,8	65,7	1 375,1
TOTAL	181,4	250,6	1 381,5

FUENTE: Ministerio de Agricultura - OIA. Estadística de Comercio Exterior. 1 993 - 1 996.

Gráfico 2. Perú: Exportación de quinua por mes - 1996



2.3 Perú: Importación

El Perú no autoabastece toda su demanda interna de quinua. Según las últimas estadísticas se ha importado en los últimos años de 96 000 kg a 562 519 kg. En términos de valor CIF, de $ 78 000 a $ 424 008 dólares (Ver Cuadro 10), siendo este crecimiento mucho mayor respecto a la exportación debido a que la quinua boliviana es más cotizada por una mejor presentación, menos impurezas, mayor tamaño de granos, cualidades que el consumidor peruano en la actualidad exige.

Cuadro 10 : Importación de quinua, según país de origen: 1 993 - 1 995.

	Cantidad (kg)			Valor CIF (US $)		
País	1 993	1 994	1 995	1 993	1 994	1 995
Bolivia	96 000	150 000	562 519	78 000	117 000	424 008

FUENTES: Ministerio de Agricultura: Estadística de Comercio Exterior Agrario.

1 993 - 1 996.

Exportaciones Tradicionales y no Tradicionales - 1 995. Secretaría Nacional de Comercio.

2.4 Bolivia y Ecuador

En cuanto a la producción de quinua en Bolivia y Ecuador, ambos países hasta el año 1990, han experimentado un crecimiento importante, tal como se puede observar en el cuadro 11. El Ecuador ha crecido significativamente por su alta productividad, obteniendo en promedio 2 000 kg/Ha frente a Perú con 860 kg/Ha y Bolivia con 644 kg/Ha, lo cual incide en que sus costos de producción sean menores, para mayor detalle, observar el cuadro 12.

En el anexo A se presenta un diagnóstico de la situación, perspectiva y bases para un programa de promoción de cultivos de quinua para el año 1 990, en los países que pertenecen a la ex-Junta del Acuerdo de Cartagena, hoy Comunidad Andina. Se observa que Bolivia ha venido trabajando con visión en las últimas décadas y con planes a largo plazo en desarrollar la quinua para su mercado interno y de exportación. Así, por ejemplo, en la Investigación Genética y Agronómica y de Transferencia de Tecnología. En cuanto a Postcosecha, Almacenamiento y Transporte cuenta con el mismo desarrollo. En Transformación Agroindustrial el Perú y Bolivia están en ventaja frente a Ecuador, porque ambos países usan alta Tecnología en el procesamiento de la quinua. En cuanto a perspectivas, el mercado interno se presentaba favorable para el autoconsumo en países como Perú, Bolivia y

Ecuador y un limitado mercado en Colombia y Venezuela; en cambio el potencial del mercado externo era alentador, debido al valor nutritivo de la quinua y sobretodo por ser un producto orgánico.

Bolivia en el año 1 990 exportó 344 508 kg de quinua a un valor FOB de $ 292 300 dólares y en el año 1 995, 1 346 511 kg por un monto de $ 1 398 871 dólares. Es decir la exportaciones en sólo seis años crecieron aproximadamente cuatro veces (Ver cuadro 13).

En 1 995, Bolivia exportó principalmente a Estados Unidos, Perú, Alemania y Ecuador, tal como se puede observar en el Cuadro 14. Cabe resaltar que Perú es uno de los principales compradores, sin considerar el ingreso ilegal (contrabando) de la quinua boliviana que se estima en alrededor de 1 500 TM/año.

En cuanto a exportación de quinua por parte del Ecuador no se tiene referencia estadística.

En años recientes, la quinua se está haciendo cada vez más popular, debido a su excepcional aporte nutritivo, en los mercados de EE. UU., Europa y Japón.

El consumo actual de quinua en USA es de aproximadamente 1 400 TM al año, la mayor parte de procedencia boliviana. El valor del mercado de exportación de quinua a los EE. UU. es de un millón de dólares anuales, aproximadamente.

Cuadro 11. Comparativo de la producción de quinua entre Bolivia, Perú y Ecuador 1982 - 1 990. (TM).

Años	Bolivia	Perú*	Ecuador
1 982	15 785	14 796	50
1 984	16 641	11 993	41
1 986	20 631	7 088	135
1 988	22 600	13 385	553
1 990	18 069	3 500	1 200

FUENTE: IICA "Estudio de Mercado y Comercialización de la Quinua Real de Bolivia", 1 991.

* ADEX/USAID/MSP/COSUDE "Quinua Estudio de la Demanda", 1 996.

Cuadro 12 : Comparación de costos de cultivo de quinua en Bolivia, Ecuador y Perú.

(datos a 1 991).

	Bolivia		Perú		Ecuador
	1/	2/	3/	4/	5/
Costos US $/Ha	218	195	331	167	348
Rend. Kg/Ha	644	552	860	415	2000
Costo US $/TM	339	353	383	402	174
Precio venta US $/TM	460	460	550	350	400
Utilidad US $/Ha	78	59	142	61	452

FUENTE: IICA. "Estudio de Mercado y Comercialización de la Quinua Real de Bolivia" (1 991).

1/ Sistema Mecanizado
2/ Sistema Tradicional
3/ Cultivo comercial
4/ Sistema Tradicional
5/ Tecnología Mecanizada y Cultivos Comerciales

Cuadro 13. Exportación Boliviana de quinua, 1 990-1 995.

Año	kilos brutos	Valor US $
1 990	344 508	292 300
1 991	619 588	621 270
1 992	484 370	563 065
1 993	541 736	670 065
1 994	1 172 548	1 446 683
1 995	1 346 511	1 398 871

FUENTES:

- Compendio Estadístico de Exportaciones no Tradicionales 1 990 - 1 994. Secretaría Nacional de Comercio - SIVEX.

- Exportaciones Tradicionales y no Tradicionales - 1 995. Secretaria Nacional de Comercio.

Cuadro 14. Bolivia: Exportaciones de quinua según país de destino, 1 995.

País Kilos brutos Valor US $

País	Kilos brutos	Valor US $
Alemania	157 969	235 430
Chile	990	1 600
Estados Unidos	480 138	593 690
Ecuador	90 000	75 040
España	895	703
Países Bajos	54 000	68 400
Perú	562 519	424 008
TOTAL	1 346 511	1 398 871

FUENTE: Exportaciones Tradicionales y no Tradicionales - 1 995. Secretaría Nacional de Comercio.

PAGE < TOC PAGE >

INPhO e-mail: inpho@fao.org
INPhO homepage: http://www.fao.org/inpho/

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

Organisation: Instituto de Desarrollo Agroindustrial (INDDA)
Author: Magno Meyhuay
Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis (Language&Style), Carolin Bothe (HTML transfer)

CHAPTER XI QUINUA: Post-harvest Operations

---

3 Composición y valor nutricional. Usos

3.1 Composición química y valor nutricional del grano de quinua y derivados

La quinua es uno de los pocos alimentos de origen vegetal que es nutricionalmente completo, es decir que presenta un adecuado balance de proteínas, carbohidratos y minerales, necesarios para la vida humana.

En el cuadro 15 se muestra la composición proximal del grano de quinua dentro de amplio rango de variabilidad.

Cuadro 15 : Valores máximos y mínimos de la composición del grano de quinua según varios autores (g/100 g).

Proteínas	11.0	21.3
Grasas	5.3	8.4
Carbohidratos	53.5	74.3
Fibra	2.1	4.9
Ceniza	3.0	3.6
Humedad (%)	9.4	13.4

FUENTE: Junge, 1975. Citado en "Quinua, el grano de los Andes".

En el cuadro 16 se compara el valor nutricional de la quinua con los de otros cereales importantes utilizados en la alimentación humana.

Cuadro 16: Valor nutricional de la quinua comparado con otros cereales.

	Quinua	Trigo	Arroz	Maíz
Valor energético Kcal/100g	350,00	305,00	353,00	338.00
Proteínas g/100g	13,81	11,50	7,40	9,20
Grasa g/100 g	5,01	2,00	2,20	3,80
Hidratos de Carbono g/100g	59,74	59,40	74,60	65,20
Agua g/100g	12,65	13,20	13,10	12,50
Ca mg/100g	66,60	43,70	23.00	150,00
P mg/100g	408,30	406,00	325,00	256,00
Mg mg/100g	204,20	147,00	157,00	120,00
K mg/100g	1040,00	502,00	150,00	330,00
Fe mg/100g	10,90	3,30	2,60	-
Mn mg/100g	2,21	3,40	1,10	0,48

Zn mg/100g	7,47	4,10	-	2,50

FUENTE: "Quinua el Grano de los Andes". Comité de Exportación de Quinua. La Paz-Bolivia.

El rango de contenido proteico va de 11 a 21,3%, los carbohidratos varían de 53,5 a 74,3%, la grasa varía del 5,3 a 8,4%. Se encuentran apreciables cantidades de minerales, en especial potasio, fósforo y magnesio (Ver cuadro 17).

Los granos contienen entre 58 y 68% de almidón y 5% de azúcares. Los gránulos de almidón son pequeños, contienen cerca del 20% de amilosa, y gelatinizan entre 55 y 65ºC.

El valor biológico de los granos se debe a la calidad de la proteína, es decir a su contenido de aminoácidos. Se encuentran cantidades significativas de todos los aminoácidos esenciales, particularmente de lisina, triptófano y cistina (Ver cuadro 18).

Cuadro 17. Contenido de minerales en quinua.

Minerales	mg/g materia seca

Fósforo	387,0
Potasio	697,0
Calcio	127,0
Magnesio	270,0
Sodio	11,5
Hierro	12,0
Cobre	3,7
Manganeso	7,5
Zinc	7,8

FUENTE: LATINRECO, 1990 (Promedio de diferentes autores)

Cuadro 18. Tabla de contenido de aminoácidos en g/100g de proteínas

Variedad	Quinua Rosada	Quinua Blanca	Quina Blanca Dulce
Proteína	12,5	11,8	11,4
Fenilalanina	3,85	4,05	4,13
Triptófano	1,28	1,30	1,21
Metionina			

Leucina	1,98	2,20	2,17
Isoleucina	6,50	6,83	6,88
Valina	6,91	7,05	6,88
Lisina	3,05	3,38	4,13
Treonina	6,91	7,36	6,13
Arginina	4,50	4,51	4,52
Histidina	7,11	6,76	7,23
	2,85	2,82	3,46

FUENTE: Collazos et al (1996). Tablas Peruanas de Composición de los alimentos.

La FAO señala que una proteína es biológicamente completa cuando contiene todos los aminoácidos esenciales en una cantidad igual o superior a la establecida para cada aminoácido en una proteína de referencia o patrón. Las proteínas que poseen uno o más aminoácidos limitantes, es decir que se encuentran en menor proporción que la establecida para la proteína patrón, se consideran biológicamente incompletas, debido a que no puede utilizarse totalmente.

Otro factor de corrección de la calidad biológica de las proteínas es la digestibilidad. La digestibilidad de las proteínas del huevo, la leche y la carne es cercana al 100%.

Los cereales y las leguminosas debido a su contenido de fibra presentan una digestibilidad menor. Se estima que la digestibilidad de la quinua es aproximadamente 80%.

La calidad de la proteína de quinua mejora después del tratamiento térmico (cocción), obteniéndose una mejor concentración de aminoácidos y desapareciendo prácticamente los aminoácidos limitantes.

Los procesos que utilizan calor seco, como el tostado y el expandido, pueden disminuir notablemente la disponibilidad de lisina, que es termolábil y además puede reaccionar con otros componentes del grano (Reacción de Maillard, por ejemplo) disminuyendo su biodisponibilidad.

La fibra soluble es importante por los beneficios que aporta el proceso de digestión, por su capacidad para absorber agua, captar iones, absorber compuestos orgánicos y formar geles, en el cuadro 19 se observa el contenido de fibra insoluble, soluble y la fibra dietética total.

Cuadro 19. Contenido de fibra insoluble, soluble y fibra dietética total (FDT) en gramos de quinua (g/100 g).

Muestra	Fibra insoluble	Fibra soluble	FDT
Quinua	5,31	2,49	7,80

FUENTE: Repo - Carrasco, 1992. Los Cultivos Andinos y la Alimentación Infantil.

3.2 Uso de subproductos de quinua.

3.2.1 Polvillo con saponina

Es el producto obtenido en el descascarado por fricción de la quinua perlada. Se usa en la fabricación de jarabe de frutas, cerveza, crema de afeitar, etc.

3.2.2 Polvillo sin saponina y granos partidos

El polvillo sin saponina es el producto resultante del pulido del grano de quinua descascarada y los granos partidos se obtienen durante el proceso de la quinua perlada. Ambos subproductos se utilizan en la alimentación de ganado y aves de corral.

3.2.3 Hojas:

La época oportuna para la utilización de las hojas de quinua en la alimentación humana es poco antes del inicio de la floración, que puede ocurrir entre los 60 y 80 días después de la germinación. El consumo de la hoja de quinua es conocido en la región andina del Perú y Bolivia y su utilización reemplazaría el de las hojas de espinaca, especie a la cual es muy afín botánicamente. En el cuadro 20 se compara la hoja de quinua fresca con otras especies hortícolas, del cual se desprende que la hoja de quinua es superior en contenido de proteína y lípidos.

Cuadro 20. Comparación en contenido de proteína y lípidos de la hoja de quinua fresca con otras hortalizas

Especie	Proteína %	Lípidos%
Quinua	3,3	2,1
Alcachofa	3,0	0,2
Cebolla	1,4	0,2
Berros	1,7	0,5
Espinaca	2,2	0,3

FUENTE: Repo Carrasco, Ritva, 1992. Los Cultivos Andinos y la Alimentación Infantil.

3.2.4 Tallos:

El estudio químico del tallo comprende generalmente tanto el tallo en sí como las hojas secas, los tallos secundarios, los pedúnculos y el rastrojo de la trilla del ganado, cuyo conjunto se denomina broza o "quiri" (quechua) y el residuo del grano "jipi" (quechua). El en cuadro 21 se observa el análisis bromatológico de la broza y el jipi. Los mayores componentes de la broza son fibra y extracto no nitrogenado.

Cuadro 21. Análisis proximal de broza y jipi de quinua

Nutrimento	Broza	Jipi
Materia Seca	92,37	90,0
Proteína, g/100g MS	7,53	10,7
Grasa, g/100g MS	1,59	-
Fibra, g/100g MS	42,90	-
Cenizas, g/100g MS	11,41	9,9
Extracto no nitrogenado g/100g MS	36,57	-

FUENTE: Elaboración propia

MS : Materia seca.

3.3 Principales formas de transformación y usos

En el cuadro 22 se muestra la composición de algunas variedades de quinua y de algunos productos derivados. Los principales productos que se obtienen de la quinua y sus usos se detallan a continuación.

3.3.1 Harina cruda de quinua

Es el producto resultante de la molienda de la quinua perlada, su finura dependerá del número de zaranda o malla que se usan en la molienda. Se utiliza en panificación, fidelería, galletaría, repostería, etc.

3.3.2 Harina Tostada de Quinua

Es el producto resultante de la quinua perlada tostada sometido a un proceso de molienda, se usa en repostería.

Cuadro 22: Composición por 100 gramos de porción comestible de diferentes

variedades de grano de quinua y productos derivados

Quinua	1 Energía kcal	2 Agua g	3 Proteína g	4 Grasa g	5 Carbohidratos g	6 Fibra g	7 Ceniza g	8 Calcio mg	9 Fósforo mg	10 Hierro mg	13 Reti mg
Afrecho de Blanca (Junín) Blanca (Puno) Cocida Cruda Dulce blanca (Junín) Dulce blanca (Puno)	347 363 376 101 374 373 360 372 341 374 368 376	14,1 11,8 10,1 79,0 11,5 11,1 11,2 11,0 13,7 7,0 10,2 12,6	10,7 12,2 11,5 2,8 13,6 11,1 11,6 12,3 9,1 8,5 12,5 19,5	4,5 6.,2 8,2 1,3 5,8 7,7 5,3 7,2 2,6 3,7 6,4 10,7	65,9 67,2 66,7 16,3 66,3 67,4 68,9 67,1 72,1 78,6 67,6 53,8	8,4 5,7 5,1 0,7 1,9 6,0 6,8 7,0 3,1 3,8 3,1 8,3	4,8 2,6 3,5 0,6 2,5 2,7 3,0 2,4 2,5 2,2 3,3 3,4	573 85 120 27 56 93 115 80 181 114 124 76	342 155 165 61 242 355 226 344 61 60 205 -	4,0 4,2 - 1,6 7,5 4,3 5,3 4,3 3,7 4,7 5,2 3,6	0 0 0 - - 0 0 0 0 0 0 0

Dulce rosada (Junín) Harina de Hojuelas de (flakes) Rosada (Puno) Sémola de											

FUENTE: Collazos et al (1996). Tablas Peruanas de Composición de Alimentos.

3.3.3 Harina instantánea de Quinua

Es la harina de quinua precocida (gelatinizada), reducida a polvo y que se dispersan rápidamente en líquidos, esta cualidad y la de poder ser consumido sin previa cocción la ponen en ventaja sobre la harina cruda para ciertos usos como en la preparación de bebidas instantáneas, uso en postres, cremas como suplemento nutritivo en cocoa y leches malteadas.

3.3.4 Quinua Perlada

Es el grano entero, obtenido del escarificado o desaponificado del grano de quinua. Se utiliza directamente en la elaboración de guisos tradicionales o indirectamente para la elaboración de harinas, hojuelas y expandidos (maná).

3.3.5 Hojuelas de Quinua

Los granos de quinua perlada son sometidos a un proceso de laminado a presión, ejercido por 2 rodillos lisos sobre los granos, lo que permite darles una forma laminada o aplanada. Este producto es consumido previa cocción y mezclado con leche en el desayuno bajo la forma de "cereal".

3.3.6 Expandido de quinua (Maná)

Se obtiene a partir de la quinua perlada, aunque algunas veces de la quinua al natural. El maná resulta de la expansión brusca de los granos obtenidos al someter estos a una temperatura alta y descompresión violenta.

En el Cuadro 23, se presenta las formas preferidas de preparación de la quinua en Lima Metropolitana, según encuesta realizada a las amas de casa en el año 1996. Se puede apreciar que mayoritariamente en Lima se prefiere consumir la quinua en guisos acompañandos de diferentes carnes.

En el Anexo B, se muestran las formas de preparación doméstica de la quinua en el Perú, Ecuador y Bolivia.

Cuadro 23. Formas preferidas de preparación de quinua en Lima Metropolitana

Formas de preparación	%
Guisarlo con diferentes carnes	67,0
Postres	36,0
Refrescos	35,3
Sopas	34,1
En el desayuno	22,3
Agua de biberón	9,6
Tipo menestra	4,4

Ajiaco	4,0
Chupe	3,8
Galletas	1,0
Bolitas de miel	0,6
Sanchochado	0,5
Licor chicha	0,4
Frito	0,2
Tostadas	0,1
Mazamorra	0,1
Otros	0,9
No sabe	0,6

FUENTE: Convenio ADEX/USAID/MSP/COSUDE "Estudio de la Demanda de Quinua", 1996.

3.4 Factores Antinutricionales de la Quinua

La quinua presenta factores antinutricionales que pueden afectar la biodisponibilidad de ciertos nutrientes esenciales, como proteínas y minerales. Son los siguientes: Saponinas, fitatos, taninos e inhibidores de proteasa.

3.4.1 Definición de saponina

El término "Saponina" se considera aplicable a dos grupos de glucósidos vegetales uno de ellos compuestos por los glucósidos triterpenoides de reacción ligeramente ácida, y el otro por los esteroides derivados del perhidro 1,2 ciclopentanofenantreno. Tienen como propiedad la de formar una abundante espuma en solución acuosa y son también solubles en alcohol absoluto y otros solventes orgánicos.

En la quinua habría tanto saponinas como ácidos neutros. Por la característica espumante, las saponinas se emplean en la fabricación de cerveza, en la preparación de compuestos para extinguidores de incendios y en la industria fotográfica, cosmética (shampoos) y farmacéutica. En esta última tiene utilidad para la elaboración sintética de hormonas. Igualmente es aprovechada por los campesinos andinos, especialmente las mujeres, quienes enjuagan sus cabellos con el agua que queda del lavado de quinua o la utilizan para lavar tejidos.

3.4.2 Efectos de la Saponina

El principal efecto de la saponina es producir la hemólisis de los eritrocitos y afectar el nivel de colesterol en el hígado y la sangre, con lo que puede producirse un detrimento en el crecimiento, a través de la acción sobre la absorción de nutrientes.

Aunque se sabe que la saponina es altamente tóxica para el humano cuando se administra por vía endovenosa, queda en duda su efecto por vía oral.

Se afirma que los medicamentos a base de saponina pueden ser administrados en grandes dosis por vía oral, ya que no son absorbidos por las mucosas intestinales y además se desdoblan bajo la acción de los álcalis y fermentos intestinales.

El efecto tóxico de la saponina de quinua sobre el organismo humano puede estar en discusión. Pero, sin duda, el sabor amargo resultante del glucósido es un estorbo para el consumo.

PAGE < TOC PAGE >

INPhO e-mail: inpho@fao.org
INPhO homepage: http://www.fao.org/inpho/

Organisation: Instituto de Desarrollo Agroindustrial (INDDA)
Author: Magno Meyhuay
Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis (Language&Style), Carolin Bothe (HTML transfer)

CHAPTER XI QUINUA: Post-harvest Operations

4 Requisitos de calidad

De acuerdo a los trabajos realizados en la Planta Piloto de alimentos del Programa de Investigación y Proyección Social en Alimentos de la Universidad Nacional Agraria La Molina, el producto final debería tener las siguientes características:

Contenido de saponina : Trazas

Humedad : 9%

Material extraño : Max. 25 mg/lb

Piedras : 0

Calificado como proceso F.V.O. : (Producto orgánico).

Los análisis de Laboratorio que se recomiendan para un producto que se va a comercializar en el mercado interno según el Instituto La Molina Calidad Total, son los siguientes:

a. Ensayos fisicoquímicos:

- Humedad

- Fibra

- Grasa

- Cenizas

- Proteína

- Carbohidratos

- Saponinas

- Análisis Físicos (granos dañados, materias extrañas)

b. Ensayos microbiológicos:

- N. aerobios mesófilos

- N. mohos y levaduras

- N. E. coli.

c. Determinación organoléptica

De acuerdo a la Norma Técnica Nacional del Perú, el grano de quinua se clasifica como grado 1, 2 o 3, según el porcentaje defectuoso u objetable, debido a variedades constrastantes, granos dañados o materias primas (Ver cuadro 24).

Cuadro 24. Requisitos que debe cumplir la quinua y calificación

	Porcentajes maximos en masa			
Grado	Variedades	Granos dañados		Materias
	constrastantes	Total	Dañados por calor	extrañas
1 2 3	3% 5% 8%	2,0% 4,0% 6,0%	0,2% 0,4% 0,8%	1,5% 3,0% 4,5%

FUENTE: ITINTEC, Norma Técnica Nacional No. 205.036, Perú, 1982.

El contenido de humedad no debe ser mayor al 14,5%. No debe tener olores objetables, ni contener residuos de materiales tóxicos, ni estar infectadas ni infestadas.

La norma no especifica niveles máximos de saponina, ni de ninguna sustancia tóxica (pesticidas, metales pesados, etc).

En la actualidad, en el Perú se ha diversificado la oferta de productos derivados de la quinua. Se tiene: quinua, perlada, harina de quinua, quinua en hojuelas, quinua expandida, galletas de quinua, bebidas a base de quinua, etc. No existiendo aún una norma específica para estos productos.

PAGE < TOC PAGE >

INPhO e-mail: inpho@fao.org
INPhO homepage: http://www.fao.org/inpho/

Home"" """""> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

PAGE < TOC PAGE >

Organisation: Instituto de Desarrollo Agroindustrial (INDDA)
Author: Magno Meyhuay
Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis (Language&Style), Carolin Bothe (HTML transfer)

CHAPTER XI QUINUA: Post-harvest Operations

---

5 Cosecha y Post-cosecha

En la precosecha la quinua está expuesta al ataque ornitológico, tal como se describe a continuación:

Las aves ocasionan daños en los últimos períodos vegetativos de la planta (estado lechoso, pastoso y madurez fisiológica del grano). Se alimentan de los granos en la misma panoja, al mismo tiempo que ocasionen la caída de un gran número de semillas por desgrane o ruptura de los pedicelos de los glomérulos.

El ataque de aves es notorio y más susceptible en las variedades dulces como Sajama, Cheweca y Blanca Juli, donde las pérdidas alcanzan hasta un 30 a 40% de la producción a obtenerse. Esto ocurre especialmente alrededor del lago Titicaca, donde bandadas de aves lacustres atacan a los campos de quinua. En los valles interandinos se observa el ataque de palomas y tórtolas (kullkus).

Para disminuir estás pérdidas se utilizan pajareros que ahuyentan a los pájaros con pitos y latas. Existe las tradición de colocar águilas disecadas en lugares estratégicos, cambiándoles de ubicación a diario, con lo cual se logra disminuir en cierto grado dicho ataque. La utilización de repelentes se está probando, últimamente se ha empleado el Nuvacron EC400 a la dosis de 3 o/o.

La cosecha tiene 5 etapas:

- Siega o corte

- Emparve o formación de arcos

- Trilla o separación de granos

- Venteo y limpieza

- Secado del grano

En el cuadro 25 se observa las mermas en las etapas de cosecha y postcosecha, las que se detallarán a continuación.

En el anexo C se muestran costos de algunos equipos empleados en la postcosecha y procesamiento de quinua.

Cuadro 25. Merma en la etapa de cosecha y postcosecha

Actividad	Merma (%)
Ataque de aves	30 a 40%
Siega o corte	5 a 10%
Transporte por acémila	1 a 5%
Emparve	5 a 10%
Trilla	5 a 8%
Venteo y limpieza	13 a 15%
Almacenamiento	---

FUENTE: Proyecto Pisca - Postcosecha - UNA - Puno

5.1 Siega

El momento adecuado es cuando las plantas llegan a la madurez que se reconoce cuando las hojas inferiores se vuelven amarillentas y empiezan a caerse. Se utilizan hoces o segaderas. No es conveniente arrancar las plantas, pues al salir junto con las raíces, traen tierra, que puede mezclarse posteriormente con el grano, desmejorando su calidad. Esta labor se realiza cuando la planta ha alcanzado su madurez fisiológica, cuando los granos tienen alrededor de 30% de humedad, para evitar pérdidas por desgrane. (Un indicador de madurez es cuando las hojas tienen un color amarillento).

Es conveniente hacerlo en las primeras horas de la mañana, cuando los glomérulos presentan una consistencia húmeda, no así en horas de la tarde, ya que los granos con la fuerte radiación solar, se desprenden con facilidad, pudiendo caer al suelo.

Las pérdidas por caídas de granos al suelo (excesiva madurez fisiológica) se estima entre 5 y 10%.

Las pérdidas producidas durante el transporte en acémilas están entre 1 y 5%.

5.2 Emparve

Consiste en la formación de arcos o parvas con la finalidad de evitar que se malogre la cosecha por condiciones climáticas (lluvias y granizadas), y en consecuencia se manche el grano.

En las parvas, las panojas se ordenan al centro, en forma de techo inclinado, y se cubren con paja, permaneciendo así hasta que los granos tengan la humedad adecuada para la siguiente etapa (12-15%). El tiempo es de 7 a 15 días.

Las pérdidas en el emparvado se deben a la germinación del grano o por ataque de pájaros y/o roedores. Estas pérdidas se encuentran entre 5 y 10%.

5.3 Trilla

Antes de iniciarla, es importante tener en cuenta la humedad del grano, que no debe ser ni muy seco ni muy húmedo (12 - 15%). Consiste en separar el grano de la planta. Se puede realizar de diversas maneras: Manualmente, empleando palos o haitanas, animales de carga, pisando con las ruedas de un tractor, etc.

Actualmente se está mecanizando esta etapa, empleándose trilladoras estacionarias, las que funcionan con la toma de fuerza de un tractor o con motor propio. En este caso es importante la regulación del cilindro de la máquina.

Mediante este proceso, se desprenden los perigonios de las semillas y la paja, obteniéndose una mezcla de broza y semillas.

Las pérdidas ocasionadas en el trillado son alrededor de 5 a 8%.

5.4 Venteo y limpieza

Cuando la trilla se ha realizado a mano, se requiere del venteo para separar las semillas de tallos y otras impurezas. Cuando se utiliza una trilladora, las operaciones de venteo y limpieza se realizan en forma simultánea.

El proceso de separación o limpieza empleando corrientes de aire se basa en el hecho de que la semilla tiene mayor peso que las impurezas, quedando en la parte más baja por su mayor densidad.

La separación se realiza en dos etapas. En la segunda, se procede a separar la semilla de la paja muy pequeña para ensacar sólo las semillas.

Las pérdidas ocasionadas se encuentran entre 13 y 15%.

5.5 Métodos de desaponificación de quinua

En la figura 1 se observa los flujogramas para la desaponificación de quinua por varios métodos.

5.5.1 Lavado por agitación y turbulencia

Utilizando zarandas o mallas metálicas accionadas manual o mecánicamente se retienen las impurezas (pajas, tierra, residuos vegetales, etc.).

Se acondiciona la quinua remojándola por 30 minutos a temperatura ambiente con el fin de facilitar la desaponificación, pues al contacto con el agua los cristales de saponina se disuelven, eliminándose posteriormente en el lavado.

El lavado se ejecuta con un equipo con camisa de calentamiento a vapor y un agitador tipo turbina de lámina plana, el cual es accionado por un motor eléctrico. Los granos de quinua son sometidos a un proceso de fricción húmeda, debido a la gran descarga turbulenta de agua caliente que se logra en el equipo. Se produce fricción intensa entre los granos y contra las paredes, lo que permite la eliminación de las cáscaras y los compuestos responsables del sabor amargo. Posteriormente se deshidrata y empaca.

5.5.2. Método de fricción o rozamiento (Escarificado o pulido).

El escarificado consiste en la separación del episperma(descascarado) y segmentos secundarios del grano de quinua, donde se concentra el mayor contenido de saponina, que le confiere el sabor amargo y astringente, impropio para poder ser aprovechado en la alimentación; el pulido pretende producir una quinua de superior calidad, cuyo efecto consiste en remover las últimas partículas de cáscara y darle al grano un aspecto más liso y limpio, que viene a ser la quinua perlada. Esta fase se realiza a través de medios mecánicos abrasivos, utilizándose equipos de características técnicas semejantes tales como:

- Acción combinada de paletas o tambores giratorios y tamiz estacionario, que permite un constante raspado de los granos de quinua contra las paredes de las mallas. El polvillo desprendido de los granos pasa a través de la malla y es separado por gravedad o mediante uso de succionadores de aire.

- Uso de máquina flanqueadora y piladora de arroz de conos concéntricos esmerilados convenientemente regulados; así como una pulidora con conos revestidos de cuero para el perlado, posteriormente se tamiza y empaca.

5.5.3 Método termomecánico en seco

Se someten a calor seco (80 a 90ºC) los granos de quinua por 10 minutos para luego extraer la cáscara por fricción en seco. Se obtiene un grano con bajo contenido de saponinas. Luego se tamiza y empaca.

5.5.4. Método químico

Para la eliminación de saponina, existe también el método químico, mediante el cual los granos de quinua son sometidos a una solución de hidróxido de sodio al 10% a 100ºC por 1.5 minutos, para luego lavar y secar. Su aplicación industrial es incipiente.

Figura 1 : Flujograma para la desaponificación de qu			
Flujo para la obtención de quinua perlada			

	M		
OPERACIONES UNITARIAS	LAVADO X AGIT. Y TURBULENCIA	FRACCION O ROZAMIENTO	TERM
RECEPCION	▨	▨	▨
LIMPIEZA	▨	▨	▨
ACONDICIONAMIENTO	▨		
ESCARIFICADO Y PULIDO		▨	
PELADO QUIMICO			
LAVADO X AGITACION	▨		
LAVADO			
DESCASCARADO TERMOMAGNETICO			▨
DESHIDRATADO	▨		

TAMIZADO			
EMPACADO			
FUENTE: Elaboración Propia			
LEYENDA:		Operación Unitaria Efectuad	

5.5.5 Método combinado

Consiste en someter los granos de quinua a medios mecánicos abrasivos (máquinas peladoras y pulidoras en seco), luego se lava los granos para extraer la saponina residual, luego se seca los granos húmedos de quinua, se tamiza y empaca.

5.6 Secado

Es conveniente secar los granos hasta alcanzar la humedad comercial (12-14%), ya que si contiene mucha humedad se pueden originar fermentaciones que desmejoran la calidad del producto.

El método de secado puede ser natural o artificial.

5.6.1 Secado natural:
El secado natural se lleva a cabo extendiendo los granos en capas finas y exponiéndolos a la acción del aire (al sol o a la sombra), por un tiempo no mayor a 15 días.

Para que el secado sea eficaz, la humedad relativa del aire no debería ser mayor de 70%, y los granos deberían ser removidos frecuentemente para una exposición uniforme.

Pese a los inconvenientes que acarrea (secado insuficiente o lento, daño por acción de agentes atmosféricos, animales y microorganismos), el secado natural se recomienda en los siguientes casos:

Cuando las condiciones atmosféricas son propicias para un secado en un lapso relativamente corto.

Cuando las cantidades que se procesan son pequeñas.

Cuando la organización de la producción y las condiciones socio-económicas no justifican la inversión en una instalación para secado artificial.

5.6.2 Secado artificial:

El secado artificial es necesario cuando se trabaja en condiciones atmosféricas desfavorables (zonas lluviosas o con alta humedad relativa), o cuando el proceso productivo exige el manejo de grandes cantidades de grano en un tiempo relativamente corto.

El método consiste en someter a los granos a la acción de una corriente de aire, previamente calentado.

Existen dos tipos de secadores artificiales:

Secadores estáticos o discontinuos, que son relativamente baratos, pero pueden procesar sólo cantidades pequeñas de grano.

Secadores continuos, de gran capacidad de secado, de alto costo y que requieren de una infraestructura más compleja, que se justifica sólo para grandes centros de producción o almacenes que trabajen con cantidades muy grandes.

5.7 Embalaje

Un empaque y embalaje adecuados contribuyen a la disminución de pérdidas debidas a factores físicos, químicos, biológicos y humanos.

Las principales funciones del embalaje son las siguientes:

Facilita la manipulación (manual o mecánica)

Reduce las pérdidas por hurto o robo.

Protege al producto contra ataques de agentes exteriores (humedad, insectos, etc.)

En cuanto a los granos, se utilizan esencialmente sacos tejidos con fibras vegetales (yute, algodón) o fibras artificiales (polipropileno).

5.8 Almacenamiento

Los granos se deben conservar en las condiciones apropiadas para garantizar su calidad sanitaria y organoléptica.

La degradación de los granos en almacenamiento se ve afectada por la combinación de tres factores ambientales:

Temperatura

Humedad

Contenido de oxígeno.

Los granos almacenados también son afectados por microorganismos, insectos, aves y roedores.

Los formas de almacenamiento de los granos son básicamente dos: en sacos, al aire libre o en almacenes, y a granel, en granos silos de diversa capacidad.

Los factores que determinan la calidad de grano o semilla durante el almacenamiento son los siguientes:

Contenido de Humedad del Grano: El grano es higroscópico, es decir que puede ganar o perder humedad del medio ambiente. Un alto contenido de agua, mayor de 14% no es deseable ni recomendable para almacenar grano de quinua.

Humedad y Temperatura ambiente: Son los factores que más afectan la calidad fisiológica de los granos durante el almacenamiento.

El almacenamiento de los granos debe hacerse en recintos secos, frescos y bien aireados y teniendo como base parihuelas de madera.

5.9 Molienda

El objetivo de la molienda es convertir los granos de quinua procesada en harina que puede ser empleada en panadería, galletaría, fidería, pastelería, etc. y los subproductos obtenidos que son empleados en la alimentación animal.

Antes de procederse a la molienda, el grano debe pasar por una limpieza para eliminar impurezas, tales como polvo, residuos vegetales, partículas extrañas, entre otros.

Luego el grano debe ser acondicionado, en caso sea necesario, para que tenga la humedad adecuada para la molienda, esto es 14% como máximo. El acondicionado puede efectuarse mediante un secado o un tostado. En el primer caso se obtendrá como producto de la molienda una harina cruda, y en el segundo caso, una harina tostada.

Mediante el acondicionado se simplifica la operación de la molienda, facilitando la extracción del salvado, y mejorando la calidad panadera de la harina.

Entre los tipos de molino más usados a nivel rural tenemos: molinos de piedra y molinos de martillo. A nivel industrial se usan también molinos de discos.

En el molino de piedra se utilizan dos piedras circulares, siendo la inferior fija y la superior giratoria. El principio de su funcionamiento es el efecto de cortadura de la piedra giratoria. Las piedras suelen estar formadas por segmentos que se mantienen unidos por una banda de hierro. Las superficies se hallan estriadas radialmente, de modo que cuando gira la piedra superior se produce un efecto de corte sobre el grano. La piedra superior se puede ajustar subiendo o bajando, variando la finura de la molienda según el tipo de harina que se requiera.

En el molino de martillos ocurre un proceso de reducción y degradación del grano procesado. Es una máquina de trabajo continuo que facilita la extracción de un constituyente determinado. La desventaja de este tipo de molino es un mayor costo de inversión y operación.

Comparando ambos tipos, la mayor extracción durante la molienda se obtiene a partir de un molino de martillos. En los molinos de piedra no se logra una alta extracción debido a que durante la salida, una parte del producto se encuentra en rotación, arrastrado durante la molturación, lo que dificulta su extracción.

Una alternativa a la molienda es el laminado. El laminado tiene por objeto la formación de hojuelas a partir de los granos de quinua, mediante su compresión entre dos rodillos metálicos lisos de giro convergente. Como resultado, los granos son convertidos en laminillas planas (hojuelas). Por efecto de la compresión, la merma no es mayor de 0.5%. El proceso se realiza en frío, y los rodillos funcionan a una velocidad tangencial de 75 m/seg.

En el cuadro 26 se presenta la composición química de las diferentes fracciones obtenidas en la molienda de la quinua.

Cuadro 26. Composición química de las diferentes fracciones obtenidas en la molienda de quinua

Análisis bromatológico	Kancolla Afrecho	Harina gruesa	Harina fina	Sajama Afrecho	Harina gruesa	Harina fina
Humedad	11,88	12,20	12,34	8,99	9,11	9,67
Proteína	14,25	11,61	7,70	13,80	13,85	11,50
Grasas	7,70	6,32	4,30	5,70	5,82	5,50
Fibra	4,50	2,02	0,69	2,80	2,32	1,20
Cenizas	3,30	2,41	1,50	2,20	2,15	1,80
Carbohidratos	58,37	65,41	73,47	66,60	66,73	70,3

FUENTE: Moreyra et al. Estudio de la utilización de la Quinua. 1 976.

Según los resultados de los análisis bromatológicos mostrado en el cuadro 26 se observa lo siguiente:

Fracciones de mayor granulometría (aquellas con mayor cantidad de cáscara) tienen mayor porcentaje de proteínas, grasas, fibras y cenizas, pero menos carbohidratos.

Se explica porque en la primera capa (episperma) se concentra la mayor cantidad de estos compuestos químicas del grano y en la parte interna (perisperma) se encuentran los almidones en mayor proporción.

La grasa proveniente del embrión se distribuye casi uniformemente en las tres fracciones en la variedad Sajama, pero es mayor en el afrecho de la variedad Kancolla.

En el cuadro 27 se observa la granulometría y el rendimiento harinero de dos variedades de quinua (Kancona y Sajama) comparados en el trigo. Se puede observar que el rendimiento harinero total de quinua es inferior a la del trigo en aproximadamente 20%, sin embargo no hay diferencias muy significativas si tomamos en cuenta únicamente los rendimientos de harina fina.

Cuadro 27. Granulometría y rendimiento harinero de dos variedades de quinua

Tamaño de gránulos	Harina de trigo	Harina de quinua	Clasificación

(mm)	%	Kancolla %	Sajama %	
Mayor que 0,487	0,0	0,0	0,0	Afrecho D
0,487 - 0,354	0,0	1,0	0,5	
0,354 - 0,25	0,5	9,0	5,0	
0,25 - 0,23	1,5	15,0	14,0	
0,23 - 0,125	29,0	24,0	24,0	Harina gruesa C
0,125 - 0,075	28,5	13,5	24,0	Harina gruesa B
Menor de 0,075*	40,5	37,5	42,5	Harina fina A
Total	100	100	100	
Harina	98	76	80,5	
Afrecho	2	24	19,5	

FUENTE : Moreyra Pablo et al: Estudio de Utilización de la quinua - 1 996.

* La apertura 0,074 mm equivale a malla 200 en el sistema Tyler

Posibles usos de las fracciones de molienda:

A : Alimento para niños como papillas, mazamorras, cremas.

A + B + C : Panificación, bizcochería, pastas, purés, sopas, cremas

D : Alimentos Balanceados
A + B + C + D : Panes integrales.

5.10 Costos

En los cuadros 28 se aprecian los costos de producción, correspondientes a un nivel tecnológico medio y en el cuadro 29 se muestra la estructura de costos de producción agrupados según los factores productivos involucrados.

De ambos cuadros se concluye que el mayor peso corresponde al rubro insumos, con aproximadamente el 60% del costo total. Los fertilizantes (nitrato de amonio, superfosfato triple y cloruro de potasio) cubren más del 50% del costo total. El costo de las semillas es de apenas 1,40 %, y el de los fitosanitarios 5,60%.

Otro rubro importante en los costos es la mano de obra, con más del 20% del costo total. Las actividades que involucran mayor número de jornales son la preparación del terreno y las labores culturales.

El costo correspondiente a herramientas y maquinaria cubre aproximadamente el 10% del costo total.

En el cuadro 30 se presenta la rentabilidad estimada de una hectárea de quinua, la que resulta ser de 34%, sin considerar costos de ensacado, ni gastos administrativos y financieros.

Entre los cereales andinos, el cultivo de la quinua sería uno de los más rentables. Su rentabilidad estaría al mismo nivel que la de la cañihua, y sería solamente inferior a la kiwicha.

En el cuadro 31 se muestran los costos de producción de la quinua perlada a partir del grano de quinua siendo el costo mas representativo el rubro materia prima (mas del 68%) seguido por el rubro materiales de empaque que representan (mas del 18%) del costo total.

En los cuadros 32 y 33 se muestran los costos de producción de las hojuelas y la harina cruda de quinua, respectivamente.

En el caso de hojuelas de quinua, el rubro mas significativo es el costo de la materia prima (en promedio 64%) y el rubro materiales de empaque (en promedio 16%). Para el rubro harina de quinua, la materia prima representa dentro de la estructura de costos el 80% y el 9% materiales de empaque.

Cuadro 28 : Costos de producción de quinua por hectárea (US $)

Actividad	Unidad	Cantidad	Costo Unitario	Costo Total	Participación %
I. Preparación del terreno - Yunta, despeje y quema - Aradura - Desterronado y mullido - Surcado	Jornal Días/Yunta Jornal Días/Yunta	1 8 4 2	1,5 3,5 1,5 3,5	1,5 28 6 7	0,42% 7,85% 1,68% 1,96%
II. Fertilización - Aplicación - Nitrato de Amonio - Superfosfato Triple - Cloruro de Potasio - Transporte de Insumos	Jornal Kilos Kilos Kilos Kilos	2 200 100 67 367	1.5 0.56 0.38 0.58 0.01	3 112 38,8 38,9 3.7	0,84% 31,38% 10,87% 10,90% 1,04%

III. Siembra - Semillas - Sembrado	Kilos Jornal	10 3	0.5 1.5	5 4,5	1,40% 1,26%
IV. Labores culturales - Deshierbo y desahije - Aporque	Jornal Jornal	15 4	1.5 1.5	22,5 6	6,30% 1,68%
V. Tratamiento fitosanitario - Aplicación - Adherente	Jornal Litros	4 1	1.5	6 20	1,68% 5,60%
VI. Cosecha, trilla y venteado	Jornal	18	1.5	27	7,50%
VII. Otros - Imprevistos (5%) - Depreciación				17 10	4,76% 2,80%
TOTAL				356,9	100%

FUENTE: Ritva Repo Carrasco (1 991). Cultivos Andinos y la Alimentación Infantil.

(Elaborado por Villanueva, M. R. y Fuertes, R.).

Cuadro 29 : Estructura de costos de producción de quinua

Concepto	Monto US $	Participación %
I. Mano de Obra II. Insumos III. Herramientas y maquinaria IV. Transporte V. Otros - Depreciación - Imprevistos (5 %)	76,50 214,70 35,00 3,70 10,00 17,00	21,40 60,204 9,80 1,00 2,80 4,80
TOTAL	356,90	100,00

FUENTE: Ritva Repo-Carrasco (1 991). Cultivos Andinos y de Alimentación Infantil.

(Elaborado por Villanueva, M. R. y Fuertes, R.)

Cuadro 30: Estimación de la rentabilidad de quinua por hectárea cultivada

Nivel Tecnológico Rendimiento/Ha (Kgs) Precio en chacra (US $/kg) Ingresos/Ha US $ Costos de producción/Ha US $ (1) Utilidad/Ha US $ (2) Rentabilidad sobre ingresos por Ha (%)	Medio 1 600 0,34 544 359.9 187,1 34,4

FUENTE: Ritva Repo Carrasco (1 992). Cultivos Andinos y la alimentación infantil.

(1) No se consideran costos de ensacado del producto.

(2) Antes de deducir gastos administrativos y financieros.

Cuadro 31. Costos de producción de quinua perlada

C o n c e p t o	Unidad de medida	Cantidad	Precio unitario	Total (S/.)

C O S T O S D I R E C T O S	Kilos	400,00	1,10	584,69
MATERIA PRIMA	hr-hombre	16,00	1,50	
				440,00
Grano de quinua	Unidades	760,00	0,03	24,00
	Unidades	15,20	3,19	
MANO DE OBRA	Unidades	760,00	0,07	19,00
				48,49
MATERIALES	hr-hombre	1,00	5,00	53,20
Empaque (bolsas de celofán)	Kw	58,00	0,12	59,99
Cartón corrugado	m^3	1,00	0,81	5,00
Etiquetas	Día	1,00	10,00	
				6,96
C O S T O S I N D I R E C T O S	Turno	1,00	0,52	0,81
	Turno	1,00	0,15	
MANO DE OBRA				10,00
INDIRECTA				0,52
SUMINISTROS Y				0,15
SERVICIOS				5,85
				30,70
Energía eléctrica				

Consumo de agua
Alquiler de local
Depreciación
Mantenimiento de equipos
Repuestos (1%)

GASTOS ADMINISTRATIVOS (5%)

C O S T O T O T A L	644,67

RENDIMIENTO COSTO DE PRODUCCIÓN UTILIDAD (15%) PRECIO DE VENTA	Kilos Kilos Kilos Kilos	380,00 380,00 380,00 380,00	1,70 0,25 1,95	644,67 96,70 741,38

Tipo de cambio: U.S. $ 1.0 = S/. 2,73

FUENTE: PELT. Proyecto Especial Lago Titicaca. Puno - Perú, 1 997.

Cuadro 32. Costo de producción de hojuelas de quinua

C o n c e p t o	Unidad de medida	Cantidad	Precio unitario	Total (s/.)
C O S T O S D I R E C T O S MATERIA PRIMA Quinua perlada MANO DE OBRA MATERIALES Empaque (bolsas de celofán) Cartón corrugado Etiquetas C O S T O S I N D I R E C T O S MANO DE OBRA INDIRECTA SUMINISTROS Y SERVICIOS	Kilos hr-hombre Unidades Unidades Unidades hr-hombre Kw m^3 Día Turno Turno	60,00 8,00 208,80 2,00 208,80 0,50 24,00 0,01 1,00 1,00 1,00	1,70 1,50 0,03 3,19 0,07 5,00 0,12 0,81 2,50 2,01 0,60	140,22 102,00 12,00 5,22 6,38 14,62 19,51 2,50 2,88 0,01 2,50 2,01 0,60 1,40

Energía eléctrica Consumo de agua Alquiler de local Depreciación Mantenimiento de equipos Repuestos (1%) GASTOS ADMINISTRATIVOS (5%)				7,61
C O S T O T O T A L				159,72

RENDIMIENTO COSTO DE PRODUCCIÓN UTILIDAD (15%) PRECIO DE VENTA	Kilos Kilos Kilos Kilos	52,20 52,20 52,20 52,20	3,06 0,46 3,52	159,72 23,96 183,68

Tipo de cambio: U.S. $ 1.0 = S/. 2,73

FUENTE: PELT. Proyecto Especial Lago Titicaca. Puno - Perú, 1 997.

Cuadro 33. Costos de producción de harina cruda de quinua

C o n c e p t o	U.M.	Cantidad	Precio unitario	Total (s/.)
C O S T O S D I R E C T O S	Kilos	400,00	1,70	777,34
MATERIA PRIMA				
	hr-hombre	12,00	1,50	680,00
Quinua perlada				
	Unidades	768,00	0,03	18,00
MANO DE OBRA	Unidades	2,00	3,19	
MATERIALES	Unidades	768,00	0,07	19,20
				6,38
Empaque (bolsas de celofán)	hr-hombre	1,00	5,00	53,76
Cartón corrugado				66,51
Etiquetas	Kw	19,75	0,12	5,00
	m^3	0,01	0,81	
C O S T O S I N D I R E C T O S	Día	1,00	10,00	2,37
MANO DE OBRA	Turno	1,00	0,91	0,01
INDIRECTA	Turno	1,00	0,27	10,00
				0,91

SUMINISTROS Y SERVICIOS	0,27 7,77 40,18
Energía eléctrica	
Consumo de agua	
Alquiler de local	
Depreciación	
Mantenimiento de equipos	
Repuestos (1%)	
GASTOS ADMINISTRATIVOS (5%)	
C O S T O T O T A L	843,86

RENDIMIENTO COSTO DE PRODUCCIÓN UTILIDAD (15%) PRECIO DE VENTA	Kilos Kilos Kilos Kilos	384,00 384,00 384,00 384,00	2,20 0,33 2,53	843,86 126,58 970,43

FUENTE: PELT. Proyecto Especial Lago Titicaca. Puno - Perú, 1 997.

5.11 Plagas en almacenamiento

Los granos de quinua y sus derivados pueden ser afectados por microorganismos, insectos, aves y roedores.

Estos agentes biológicos pueden dañar el grano desde antes de la cosecha, e incluso algunos (microorganismos e insectos) pueden atacarlos sin que se perciba daño alguno en apariencia, pero que se manifestará posteriormente durante el almacenamiento.

Se creía que aves, insectos y roedores no atacaban al grano de quinua, porque la saponina que contiene actuaba como un repelente natural contra tales agentes, pero en la actualidad se comprueba que esto no es así, y que el agricultor debe estar prevenido para evitar que su cultivo sufra grandes estragos.

Los microorganismos (mohos y bacterias) pueden deteriorar el valor nutritivo y las características organolépticas de los productos. Estos pueden desarrollarse dentro de un amplio rango de temperatura (-8ºC a 80ºC) si la humedad relativa del ambiente es mayor a 65% -70%.

Las infestaciones por insectos pueden producirse antes de la cosecha, o en el mismo almacenamiento. Además de degradar los productos, dañan la calidad y merman el valor comercial, como resultado de su actividad biológica. Además, su presencia favorece el desarrollo de microorganismos. Requieren temperaturas entre 15ºC y 35ºC para desarrollarse.

Microorganismos e insectos son inhibidos por niveles de humedad relativa inferiores al 65% - 70% y medios pobres en oxígeno.

Las aves atacan a la quinua principalmente en el campo, pero también pueden afectar al producto cuando se almacena a granel y en silos no completamente aislados del exterior.

Los roedores suelen instalarse dentro del almacén o en su cercanía, ocasionando daño al producto, inclusive si esta embalado. Las pérdidas originadas son por degradación del producto, daño a las instalaciones y a los embalajes, disminución de la calidad comercial, organoléptica y sanitaria a causa de la contaminación por residuos biológicos.

Las medidas para combatir las plagas pueden ser de dos tipos:

- Medidas preventivas, antes de que se presente el problema

- Medidas curativas, para contrarrestar un problema durante el almacenamiento, o antes, si es que logra detectarse.

Respecto a las instalaciones, es necesario poner en práctica un plan de higiene y saneamiento general, para evitar la presencia de microorganismos, insectos y roedores. Se debe proceder con una limpieza exhaustiva, sistemática, complementada con el uso de desinfectantes, insecticidas, fumigaciones, cebos y trampas, según los casos.

El tratamiento de los granos se realiza principalmente para prevenir o contrarrestar la acción de los insectos. Los métodos usados pueden ser físicos, biológicos, mecánicos y químicos, siendo los más empleados los métodos químicos.

Los métodos químicos contra infestaciones de insectos son básicamente de dos tipos:

- Por insecticidas de contacto, que tienen un efecto rápido y una acción más o menos persistente, pero superficial, no alcanzando a las formas localizadas en el interior del grano (huevos o larvas). Puede quedar algún residuo tóxico en el producto.

- Por fumigación, empleando una sustancia química gasificada muy tóxica y con gran poder de penetración. Debe ser aplicado por personal especializado, siguiendo estrictas normas de seguridad. Los fumigantes más empleados son bromuro de metilo y fosfuro de hidrógeno.

Existe poca información respecto a métodos biológicos empleados para contrarrestar plagas en almacenamiento.

Una alternativa interesante para evitar o minimizar el uso de sustancias químicas en el Laboratorio sería mediante el empleo de técnicas de almacenamiento con atmósfera controlada empleando baja concentración de oxígeno, baja temperatura y baja humedad, condiciones que se dan naturalmente en las principales zonas de producción arriba de los 3 000 metros de altitud en la región andina.

5.12 Mano de Obra involucrada

De acuerdo a la información sobre la superficie cosechada a nivel nacional (cuadro 4) y estudios sobre la estructura de costos por hectárea correspondientes a un nivel tecnológico medio (cuadro 28), se infiere que la cosecha y postcosecha de quinua insumiría cerca de medio millón de jornales, de los cuales más de la mitad serían cubiertos por mujeres.

6 Bibliografía

ADEX, "Quinua. Estudio de la demanda". Convenio ADEX/USAID/MSP/COSUDE. Lima-Perú, 1 996.

ANAPQUI. "Alimento nutritivo de los Andes para el Mundo". Asociación Nacional de Productores de Quinua. La Paz - Bolivia.

CASTRO VICENTE, CLARA. "Evaluación de la molienda de cereales y tubérculos procesados en molino hidráulico rústico mejorado, molino hidráulico rústico y molino de martillo". Primer Taller del Proyecto Postcosecha sobre Cultivos Andinos. IICA/CIID/UNSAAC/UNA. 1 986.

CEPAL. "Análisis de cadenas agroindustriales en Ecuador y Perú". Serie Estudios e Informes de la CEPAL Nº 87. Santiago de Chile. 1 993.

DELGADO M, PEDRO. "Control de plagas de los cultivos de Quinua y Cañihua".

DE LUCÍA, M. Y D. ASSENNATO. "La Ingeniería agraria en el desarrollo, manejo y tratamiento de granos postcosecha". Boletín de Servicios Agrícolas de la FAO Nº 93. Roma, 1 993.

FAO. "Informe: Evaluación de calidad de granos en América Latina. Propuesta para uniformar el sistema de evaluación". Oficina Regional de la FAO para América Latina y el Caribe. 1 995.

FAO. "Manual sobre utilización de los cultivos andinos subexplotados en la alimentación". Oficina Regional de la FAO para América Latina y el

Caribe. 1 992.
IICA. "Estudio de Mercado y Comercialización de la Quinua Real de Bolivia". 1 991.

INIA. "Cultivo de quinua amarillo Marangani (*Chenopodium quinoa* Wild)". Serie plegable Nº 10-93. Lima-Perú. Julio, 1 993.

INIA. "Ayacuchana INIAA, Nueva variedad de quinua". Serie Plegable Nº 3-97. Lima-Perú. Mayo, 1 997.

INIA, "El cultivo de quinua Chenopodium quinoa Wild". Serie plegable Nº 7-97. Lima-Perú. Junio, 1 997.

INIA. "Variedad de quinua Quillahuaman INIA". Serie plegable Nº 10-97. Lima-Perú. Julio, 1 997.

INSTITUTO NACIONAL DE SALUD. Centro Nacional de Alimentación y Nutrición. "Tablas Peruanas de Composición de

Alimentos". Sétima Edición. Lima-Perú, 1 996.

ITINTEC. Perú Norma Técnica Nacional. "Cereales Quinua y Cañihua". Itintec 205.036. Febrero, 1 982.

ITINTEC. Perú Norma Técnica Nacional. "Harinas sucedáneas procedentes de cereales". Itintec 205.045. Febrero, 1 976.

JUNAC. "Estudio sobre la investigación, transferencia de tecnología, producción, transformación agroindustrial y comercialización de las especies nativas en el Ecuador" Quito-Ecuador. Octubre, 1 990.

JUNAC. "Situación, Perspectivas y Bases para un programa de promoción de cultivos y crianzas andinos". I Foro Internacional para el Fomento de cultivos y crianzas andinos. Noviembre, 1 990.

MARCA VILCA, SATURNINO, "Cosecha y Post-cosecha en el cultivo de la Quinua".

MUJICA, ANGEL. "Cultivo de Quinua". Ministerio de Agricultura. Instituto de Investigación Agraria. Lima - Perú. Agosto, 1 997.

PELT. Informes de Costos de Producción. Proyecto Especial Lago Titicaca. Puno - Perú, 1 997.

RITVA REPO - CARRASCO. "Cultivos Andinos y la Alimentación Infantil". Lima - Perú. 1 992.

SECRETARÍA NACIONAL DE INDUSTRIA Y COMERCIO. "Quinua, el grano de los Andes". Comité de exportación de Quinua. La Paz-Bolivia.

SIVEX. "Compendio Estadístico de exportaciones no tradicionales 1 990 - 1 994". Secretaría Nacional de Comercio.

SIVEX. Exportaciones Tradicionales y no Tradicionales 1 995. Secretaría Nacional de Comercio.

TAPIA, MARIO. "Cultivos andinos subexplotados y su aporte a la alimentación". 2da. Edición. FAO, 1 997.

TECNO IBTA. "Mecanización del cultivo de la quinua en el Altiplano Sur. Boletín Técnico del Instituto Boliviano de Tecnología Agropecuaria - Junio 1 995.

UNA - PUNO. Proyecto Pisca - Post Cosecha. "Diagnóstico Preliminar de Tecnología Campesina de post cosecha de los cultivos andinos". Cuzco, 1 986.

PAGE < TOC PAGE >

INPhO e-mail: inpho@fao.org
INPhO homepage: http://www.fao.org/inpho/

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

Organisation: Instituto de Desarrollo Agroindustrial (INDDA)
Author: Magno Meyhuay
Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis (Language&Style), Carolin Bothe (HTML transfer)

CHAPTER XI QUINUA: Post-harvest Operations

---

7 Anexos

ANEXO A: SITUACIÓN, PERSPECTIVA Y BASES PARA UN PROGRAMA DE PROMOCIÓN DE CULTIVOS DE QUINUA

I. Investigación genética y agronómica

	Países		
Producto	Bolivia	Ecuador	Perú
Quinua	4	3	3

Criterios de calificación

Descripción de las características de las especies

Alguna Experimentación

Tecnología incipiente

Impacto significativo sobre la productividad

Paquete Tecnológico Completo.

II. Transferencia de tecnología

	Países		
Producto	Bolivia	Ecuador	Perú
Quinua	3	2	2

Criterios de calificación

No existe

Incipiente

Mediana cobertura

Buena cobertura

III. Situación en post cosecha, almacenamiento y transporte.

	Países		
Producto	Bolivia	Ecuador	Perú
Quinua	2	2	2

Criterios de calificación

Incipiente nivel de desarrollo

Medio nivel de desarrollo

Buen nivel de desarrollo

Optimo nivel de desarrollo

IV. Transformación agroindustrial

	Países		
Producto	Bolivia	Ecuador	Perú

Quinua	3	2	3

Criterios de calificación

Se procesa a nivel artesanal

Se procesa a nivel industrial con Tecnología de Desarrollo Intermedio.

Se procesa a nivel industrial con alta tecnología

V. Potencialidad de los mercados interno y externo

	Potencial de mercado interno					Potencial
Producto	Bolivia	Colombia	Ecuador	Perú	Venezuela	Mercado externo
Quinua	4	2	4	4	2	4

Criterios de calificación:

Ningún potencial

Limitado potencial

Potencial medio

Potencial alto

FUENTE: Junta del Acuerdo de Cartagena. Situación, perspectiva y bases para un programa de promoción de cultivos y crianzas andinas: I Foro Internacional para el Fomento de Cultivos y Crianzas Andinos 12-15 de noviembre de 1 990.

ANEXO B: FORMAS DE PREPARACIÓN DOMESTICA EN BOLIVIA, PERÚ Y ECUADOR.

1. Algunas preparaciones tradicionales elaboradas con quinua:

A. Sopas

- Lawa de sopa (Bolivia y Perú)

- Sopa de quinua (Ecuador)

B. Segundos o platos fuertes

- Segundo de quinua (Bolivia)

- Tortilla de quinua (Ecuador)

C. Preparaciones varias

- Pesque de quinua (Bolivia y Ecuador)

- Pizzara (Phisara) (Bolivia)

D. Panificación

- Quispiña de quinua (Bolivia y Perú).

E. Bebidas

- Api de Quinua (Bolivia y Perú).

- Champus de Quinua (Ecuador)

- Chicha Blanca de Quinua (Bolivia y Perú).

2. Algunas preparaciones no tradicionales elaboradas con quinua.

A. Sopas

- Lawa de Quinua (Bolivia)

- Sopa de Quinua con vegetales (Ecuador)

B. Guisos

- Guiso de Hojas de Quinua (Bolivia)

C. Segundos o platos

- Bife apanado con quinua graneada (Bolivia)

- Chaulafan de Quinua (Ecuador)

- Humita dulce de Quinua (Bolivia)

- Pastel de Quinua al horno (Bolivia)

- Quinua graneada con arroz seco (Ecuador)

D. Postres y dulces

- Manjar Blanco de Quinua (Bolivia)

- Pasteles de Quinua con plátano (Ecuador)

- Postre de Quinua con fruta (Perú).

E. Panificación y pastelería

- Galletas de Quinua (Bolivia)

- Queque de Quinua (Ecuador)

3. Algunas preparaciones para niños menores de cinco años elaborados con quinua.

- Hojuelas de Quinua con leche.

- Mazamorra de Quinua.

- Mazamorra de Quinua con naranja.

- Papilla de oca con Quinua

- Puré de Hojas de Quinua

- Puré con Quinua con papa.

ANEXO C: COSTO DE EQUIPOS EMPLEADOS EN POSTCOSECHA Y PROCESAMIENTO DE QUINUA.

Cuadro 34: Costo de equipos para obtención de harina de quinua y expandidos

Denominación	Costo (US $)
Tostadora de laboratorio Molino de Martillos 100 kg/h Molino de Discos 150 kg/h	200 3 186 5 900

Molino de Piedra 85 kg/h	2 950

FUENTE: Proyecto PELT

Industrias Tecnológicas Dinámicas

Cuadro 35: Costos de equipos utilizados para la desaponificación de quinua por el método húmedo.

	Secado convencional (250 kg/h)		Secado solar (5 TM/18 h)	
Denominación	Equipos	Nº de personal	Equipos	Nº de personal
- Trilladora de granos	1 508	1	1 508	1
- Venteadora de granos	22	1	22	1
- Clasificadora	2 832	1	2 832	1
Despedradora	4 130	1	4 130	1
- Lavadora de granos	2 124	1	2 124	1
- Centrífuga	2 596	1	2 596	1

- Secador tipo túnel	7 316	2	-	-
- Secador solar	-	-	2 500	5
- Cosedora de sacos	1 200	1	1 200	1
TOTAL	21 928	9	17 112	12

FUENTE: Herrandina

Industrias Tecnológicas Dinámicas

Cuadro 36: Costos de equipos utilizados para la desaponificación de quinua por método seco o escarificado (500 kg/h).

Denominación	Equipos (US $)	Nº de personal
Trilladora de granos	1 508	1
Venteadora de granos	222	2
Ciclón	500	1
Clasificadora	2 832	1
Despedradora	4 130	2

Escarificador	6 136	-
Cangilones (2)	3 540	1
Cosedora de sacos	1 200	
TOTAL	20 068	8

FUENTE: Herrandina

Industrias Tecnológicas Dinámicas

Proyecto PELT.

LISTADO DE FOTOGRAFIAS

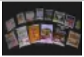
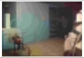
Foto 1	Germoplasma de quinua existente en la Estación Experimental de Illpa - Puno.	
Foto 2	Algunas presentaciones de quinua existentes en el mercado nacional.	
Foto 3	Agricultor altoandino con panoja de quinua para emparvado	

		
Foto 4	Cosecha mecanizada de quinua en Huancayo.	
Foto 5	Trilladora semi-industrial empleada para quinua	
Foto 6	Venteadora semi-industrial empleada para quinua	
Foto 7	Venteado de quinua con tecnología tradicional en Cuzco	
Foto 8	Clasificadora de granos a nivel piloto	
Foto 9	Escarificadora de granos a nivel piloto	
Foto 10	Escarificadora semi-industrial para quinua	
Foto 11	Escarificadora industrial para quinua	

Foto 12	Grano perlado de harina de quinua	
Foto 13	Presentación de quinua perlado para exportación al mercado japonés	
Foto 14	Tostadora de granos o "cañoncito" empleado para la obtención de productos expandidos (maná de quinua)	
Foto 15	Clasificadora semi-industrial de granos	
Foto 16	Secador estacionario de bandejas para granos	
Foto 17	Secado natural de quinua en Puno	

PAGE < TOC PAGE >

INPhO e-mail: inpho@fao.org
INPhO homepage: http://www.fao.org/inpho/

PAGE < TOC PAGE >

Organisation: International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria (http://www.cgiar.org/iita/)
Author: Mpoko Bokanga
Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis (Language&Style), Carolin Bothe (HTML transfer)

CHAPTER XII CASSAVA: Post-harvest Operations

1. Introduction

Cassava (*Manihot esculenta* Crantz) is the fourth supplier of dietary energy in the tropics (after rice, sugar and maize) and the ninth world-wide. Its cultivation and processing provide household food security, income and employment opportunities for 500 million people in Africa, Asia and the Americas. The crop is tolerant of low soil fertility, drought and most pest and diseases with no critical date of harvest. These attributes have made cassava into a crop of primary importance for the food security of farmers living in fragile ecosystems and socially unstable environments. However, in communities having access to markets, cassava can become a source of income and employment for both men and women.

It is estimated that 164 million tons of cassava roots were produced in 1995 (FAOSTAT, 1997). Slightly more than half of that amount was produced in Africa, and the rest in Asia and Latin America. The major producing countries are Nigeria, Brazil, Thailand, D.R. Congo, and Indonesia, which together account for two thirds of the world production (See Table 1).

Cassava is a staple food in tropical countries and provides more than 10 percent of the daily dietary caloric intake to about 300 million people in 15 African countries and in Paraguay (See Table 2). In the Democratic Republic of Congo, cassava is estimated to provide more than 1000 kcal/day to over 40 million people. However, in Thailand, the third world largest producer, cassava contributes less than 1 percent to the dietary calories: about 90 percent of total production are exported mainly to Europe; the remaining amount is mostly used in industrial applications.

Despite its importance, cassava is mostly grown by small farmers on small plots of land. Urban consumers and factories obtain their cassava from rural areas where it is grown. Cassava is usually processed immediately after it is taken from the ground because it is highly perishable. Spoiling starts within 48 to 72 hours after harvest.

A mature cassava root (hereafter referred to as 'root') may range in length from 15 to 100 cm and weigh 0.5 to 2.5 kg. Circular in cross-section, it is usually fattest at the proximal end and tapers slightly towards the distal portion. It is connected to the stem by a short woody neck and ends in a tail similar to a regular fibrous root (See Figure 1).

The central pith constitutes the bulk of the root and is primarily a storage parenchyma harbouring a multitude of xylem vessels. A thin layer of cambium mainly responsible for the root expansion surrounds the storage parenchyma whose cells accumulate large starch granules. At the centre of the parenchymal tissue, the primary xylem is organised in a fibrous vascular bundle.

Table 1. Production of cassava in Africa, Asia and the Americas, and in selected countries in 1995

		Production (million tons)	Yield (ton/ha)	Area Harvested (thousand ha)
World		165.3	10.1	16,240
Africa		84.4	8.4	9,880
	Nigeria	31.4	10.7	2,940
	Congo, D.R.	18.0	8.3	2,100
	Ghana	6.9	13.3	520
	Tanzania	6.0	10.2	585

	Mozambique	4.2	4.2	986
	Uganda	3.0	7.5	350
	Madagascar	2.4	7.2	336
	Angola	1.7	4.1	410
	Côte d'Ivoire	1.6	5.0	610
	Cameroon	1.3	16.3	80
	Benin	1.1	8.1	141
Asia		48.5	13.3	3,634
	Thailand	18.2	14.0	1,297
	Indonesia	15.4	12.2	1,266
	India	6.0	23.5	255
	China	3.5	15.2	230
	Viet Nam	2.5	8.9	281
	Philippines	2.0	8.7	215

South America		31.4	12.5	2,512
	Brazil	25.5	12.9	1,981
	Paraguay	2.6	14.9	175
	Colombia	1.9	9.7	198
North and Central America (Mexico and the Caribbean)		1.0	5.1	198

Source: FAOSTAT, 1997

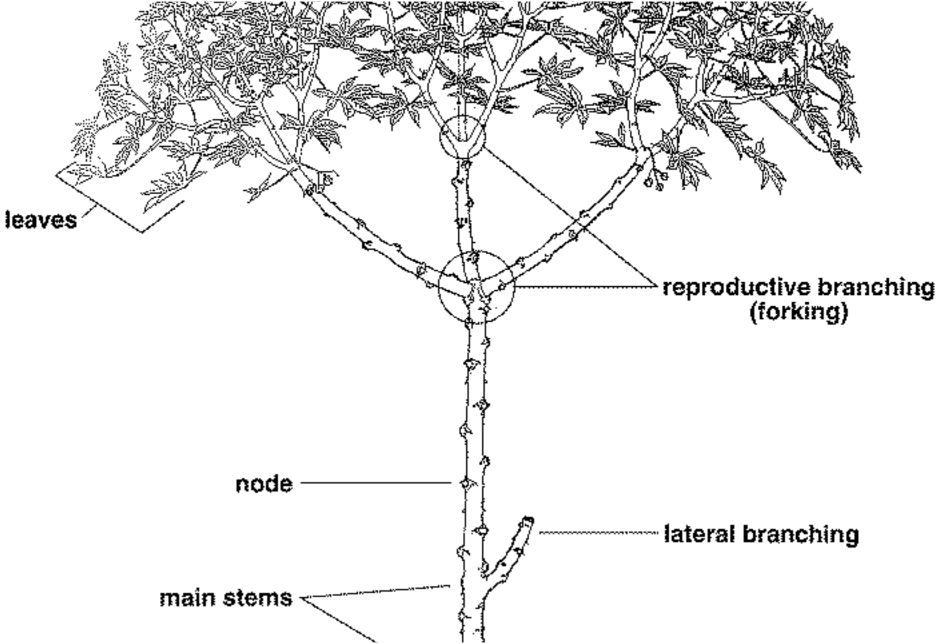
Table 2. Contribution of cassava to dietary calories in selected countries, 1992-1994

Country	Amount per person (kcal/day)	Percentage of total dietary energy (%)	Population (million)
Congo D.R.	1099	54.1	41.241

Mozambique	608	36.1	15.121
Congo R.	726	33.2	2.443
Angola	502	28.6	10.279
Ghana	625	26.5	16.450
Central Africa R.	485	24.8	3.156
Tanzania	452	22.0	28.023
Benin	456	19.6	5.087
Madagascar	339	16.5	13.858
Togo	324	15.8	3.886
Nigeria	405	15.6	105.287
Uganda	302	14.0	19.941
Paraguay	329	13.9	4.701
Cameroon	279	12.9	12.526
Côte d'Ivoire	300	12.7	13.319
Gabon	271	11.0	1.248
Burundi	169	9.4	6.027

Guinea	204	8.7	6.308
Chad	108	5.9	6.013
Sierra Leone	107	5.7	4.298
Indonesia	127	4.9	191.676
Kenya	86	4.5	26.388
Brazil	111	4.0	156.483
Vietnam	79	3.4	71.331
Colombia	87	3.3	33.958
Fiji	85	2.8	0.758
Philippines	55	2.3	64.805
Cuba	52	2.1	10.874

Source: FAO, 1996. Food Balance Sheets, 1992-1994.


leaves
reproductive branching
(forking)
node
lateral branching
main stems

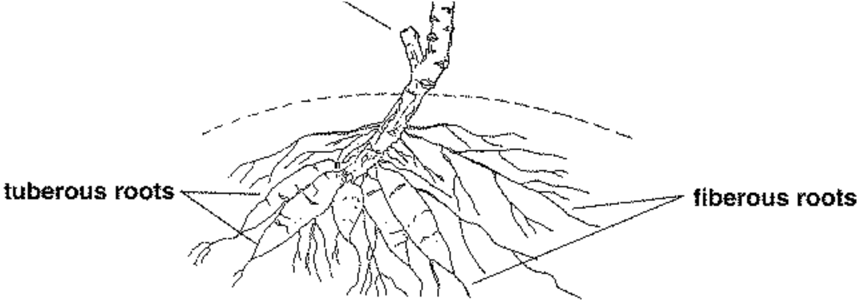


***Figure 1**: Diagram of a cassava plant*

A transversal section of the root (See Figure 2) reveals three distinct parts: the peel, the central pith, and the vascular bundle. The peel is usually not considered suitable for human consumption, but can be used for feeding pigs. The central pith is the edible portion; it constitutes the bulk of the root and is primarily a storage parenchyma harbouring a multitude of xylem vessels. A thin layer of cambium mainly responsible for the root expansion surrounds the storage parenchyma whose cells accumulate large starch granules. At the centre of the parenchymal tissue, the primary xylem is organised in a fibrous vascular bundle.

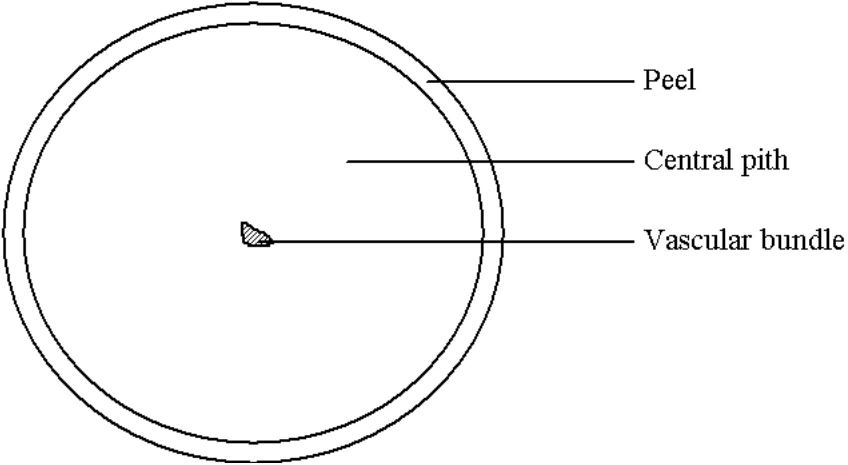


Figure 2: *Transversal section of a cassava root.*

Although the tuberous roots of cassava constitute the economically important part of the plant, the younger leaves are also consumed as vegetable in many countries. In countries such as the Democratic Republic of the Congo, Tanzania, Sierra Leone, Liberia and Guinea, cassava leaves are a major component of the diet; in other countries they are less preferred and are only consumed in times of food shortage.

In Africa, peeling of cassava roots is common and is labour-intensive. However, for *farinha* production in Brazil, cultivars such as «Branca de Santa Catarina» with a white peel have been selected so that they can be processed without removing the peel, thus considerably reducing the labour cost.

Cassava roots mainly contain carbohydrates, of which 80% is starch. The levels of protein (1-2%) and fat (less than 1%) are not nutritionally significant. However, the approximate composition (See Table 3) and micronutrient content (See Table 4) of the leaves compare favourably well with other foods such as soybean and maize grain, and amaranth leaves (West et al., 1988).

Table 3. Approximate composition (% of fresh weight) of cassava leaf, amaranth leaf, soybean and yellow maize. (In brackets the percentage on dry matter basis.)

Moisture		Protein	Fat	Carbohydrates	Fibre	Ash
Cassava leaf	72.0	7.0 (25.0)	1.0 (3.6)	14.0 (50.0)	4.0 (14.3)	2.0 (7.1)
Amaranth leaf	84.0	4.6 (28.8)	0.2 (1.3)	7.0 (43.8)	1.8 (11.3)	2.9 (18.1)
Soybean	11.0	34.0 (38.2)	18.0 (20.2)	29.0 (32.6)	4.7 (5.3)	5.0 (5.6)
Maize (yellow)	10.0	10.0 (11.1)	4.8 (5.3)	72.0 (80.0)	2.0 (2.2)	1.2 (1.3)

Source: West et al., 1988.

Table 4. Mineral and vitamin content of 100 g of cassava leaf, amaranth leaf, soybean and yellow maize

	Ca	Fe	ß-carotene	Thiamin	Riboflavin	Niacin	Vit. C
	(mg)	(mg)	(µg)	(mg)	(mg)	(mg)	(mg)
Cassava leaf	300	7.6	3,000	0.25	0.60	2.4	310
Amaranth leaf	410	8.9	2,300	0.05	0.42	1.2	50
Soybean	185	6.1	28	0.71	0.25	2.0	0
Maize (yellow)	13	4.9	125	0.32	0.12	1.7	4

Source: West et al., 1988.

The nutritional value of fresh foods that are actually consumed after some kind of processing is only indicative of the potential contribution of these foods to the nutrition of the consumer. The composition of prepared foods should be considered for a better evaluation of the quality of these foods. The literature is scant on this aspect, but it has been shown that most processes to which cassava is submitted in the preparation of food products lead to reductions in protein, vitamin and mineral content (Lancaster *et al.,* 1982).

Protein is reduced by 50 to 87 percent in the preparation of foodstuffs from cassava roots in Cameroon, while vitamin C, niacin and thiamine are almost entirely lost (Favier *et al.,* 1971). Riboflavin, on the other hand, has been found in higher quantities in some fermented cassava products than in fresh cassava roots, and it has been suggested that this vitamin may be synthesised during fermentation (Favier *et al.,* 1971; Watson, 1976).

Data on the loss of nutrients during the preparation of cassava leaves are even more rare. Protein is reduced as in the preparation of cassava roots. Vitamin C is reduced by more than half when the leaves are boiled for 10 minutes (Watson, 1976). The remaining concentration of nutrients does, however, still provide a good contribution to the daily requirements (Lancaster and Brooks, 1983).

Cassava roots should be considered as merely a source of carbohydrates or calories for the diet. Their main advantage is their low cost. Thus, energy requirements can be met at a low cost and a larger proportion of the income can be devoted to other foods and/or needs. This is important on two counts: first, it makes it easier for poor populations for whom cassava is the main staple to afford other items of their diet; and second, it makes much nutritional sense since meeting one's energy requirements has been recognised as a prerequisite for a good utilisation of other elements such as proteins in the diets (FAO/WHO, 1973). It has been recently shown that cassava is a good source of energy and that it interferes very little with the digestion of added protein and fat in weaning diets (Morales and Graham, 1987). A positive effect of cassava on the metabolism of cholesterol in the rat has also been reported (Brydon, 1982). These arguments encourage the utilisation of cassava and call for more research on this crop.

1.2 World Trade

The annual global supply of cassava has increased steadily at a rate of 2.3 percent per year between the 1972-74 and the 1992-94 periods (see Tables 5 and 6) to reach an additional supply of 60 million tons of fresh root equivalent per year. The increase was more pronounced in Africa which averaged a growth rate of 3.4 percent in the same period. Cassava production grew at a rate of 2.6 percent in the 1970s and of 4.2 percent in the 1980s. The main reason for this increase were insufficient alternative food supplies, demographic pressures and failure of other crops during droughts, and in some countries such as Ghana, policies intended to promote cassava and in Nigeria policies to reduce cereal imports. Between 1985 and 1995, cassava production in Ghana and in Nigeria grew at an annual rate of 11.0 percent and 8.4 percent respectively. This rapid increase was due to both expansions in area cultivated and to increases in yields due to the adoption of high-yielding varieties by cassava farmers. Growth rates were more modest in many countries, and were negatives in Mozambique, Tanzania and Uganda.

In Latin America production of cassava declined at a rate of -1.3 percent per year in the 1970s and had a small annual increase (0.2 percent) in the 1980s. This stagnation was mainly caused by a lack of production incentives. In addition, Brazil, which grows 80 percent of the cassava in the region, was hit by a long drought, which reduced yields. However, there is a wide disparity in cassava yields across Brazil: while average yields stand at 4-8 ton/ha in Northeast Brazil, they jump at 20-28 ton/ha in the southern states of Parana and Sao Paulo. In Colombia, cassava production grew at an average annual rate of 1.6 percent per year. Between 1985 and 1995, the annual increase was actually 3.4 percent. This strong performance in a region where cassava production is declining may be related to policies put in place by the Government of Colombia to provide better access to credit and technical assistance by cassava farmers.

Thailand and Indonesia account for the largest share (75 percent) of cassava produced in Asia. In the 1970s, cassava production grew rapidly (5.1 percent annually) due to both yield increase (2.6 percent) and expansion of cultivated land

(2.6 percent). This rapid increase in cassava production was due to a growing demand for cassava pellets and starch for export to countries of the European Union. In Thailand, cassava production went from 1.2 million tons in 1960 to about 23 millions tons in 1990. Between 1965 and 1980, production doubled every five years. Like elsewhere cassava is grown, production is primarily in the hands of small scale producers; but in Thailand, cassava farmers averaged yields exceeding 15 tons per hectare compared to a world average of less than 10 tons per hectare. In the late 1980s and early 1990s, the rate of growth in cassava production has slowed down considerably.

Table 5. Cassava production, yield and cultivated area per region, 1972-1994.

Region	Production (million ton)	Yield (ton/ha)	Area harvested (million ha)
	1972-74 1982-84 1992-94	1972-74 1982-84 1992-94	1972-74 1982-84 1992-94
World	102.2 129.5 162.3	8.2 9.3 9.9	12.4 13.9 16.4
Africa	41.5 54.0 82.1	6.0 7.1 8.2	6.9 7.6 10.0
Americas	32.8 28.9 29.5	12.1 10.8 11.6	2.7 2.7 2.6

Asia	27.8 46.4 50.6	9.8 12.7 13.1	2.8 3.7 3.9

Source: FAOSTAT, 1997

Table 6. Growth rates in cassava production, yield, and area harvested between the periods 1972-1974 and 1982-1984 (indicated as 1973-83) and between the periods 1982-1984 and 1992-1994 (indicated as 1983-93).

Region	Production (percent)		Yield (percent)		Area harvested (percent)	
	1973-83	1983-93	1973-83	1983-93	1973-83	1983-93
World	2.4	2.3	1.3	0.6	1.1	0.3
Africa	2.6	4.2	1.7	1.4	1.0	2.7
Americas	-1.3	0.2	-1.1	0.7	-0.2	-0.5
Asia	5.1	0.9	2.6	0.3	2.6	0.5

.Source: FAOSTAT, 1997

In the late 1980s and early 1990s, the European Union imposed a restrictive quota system. Unable to export all of their production, cassava producers in Thailand have begun looking for alternative markets abroad, but also at home. Strong industry-led economic growth pushed cassava cultivation to marginal lands, leading to a decline in productivity (Henry and Gottret, 1995). In Indonesia, a large proportion of the cassava produced is consumed internally. A strong economy and rising incomes have increased demand for cassava starch. Adoption of high-yielding varieties has contributed to an annual production growth rate of 1.4 percent since the mid-1980s.

1.3 Primary product

Wherever cassava is grown, it is primarily used as food. The exception to this rule is Thailand where 90 percent of the cassava produced is exported and the rest is used in industries. In Africa, close to 90 percent of cassava produced is used as food, with very little used for animal feed and even less for export and industries (See Table 7). Post-harvest losses have been estimated at 9.5 percent. In Asia, over half of the cassava production is used as food. Exports account for 27 percent and come primarily out of Thailand and Indonesia. In Latin America and the Caribbean, cassava is used mainly as food (42 percent) and feed (33 percent). The use of cassava in industry accounts for 10 percent of the production in the Americas, 9 percent in Asia, and 0.1 percent in Africa.

Table 7. Uses of cassava by continent (in percentage of production)

Producing region	Food	Feed	Industry	Export	Waste
Africa	88.7	1.4	0.1	0.1	9.5
Asia	55.3	2.9	8.6	26.9	6.3
Americas	42.4	33.4	9.6	0.1	14.0

Source: FAOSTAT, 1997

Cassava has traditionally played an important role as an irreplaceable food security crop in large parts of the developing world. In addition, cassava has increasingly received attention as a low-cost, high quality raw material for both small and large scale manufacturing of a wide range of processed products for growing national markets and for exports.

Africa

Almost all cassava grown in Africa is for human consumption; 30 percent is consumed after peeling, cleaning and boiling, while 70 percent is processed into a wide variety of food products including dry chips and flour, cooked pastes, roasted or steamed granules, beverages, etc. Both rural and urban peoples use these products as a basic daily source of dietary energy. The diversity of products is matched by a proliferation of common names for these foods: the same name could refer to different food products (e.g. *foofoo* or *fufu* is a different product in Ghana, Nigeria and Congo), while the same food product can have different names in different locations (e.g. *kwanga* or *chikwanghe* in Congo, *bobolo* or *miondo in* Cameroon refer to a similar product).

The most popular product in West Africa is *gari*, a free-flowing, granular, fermented and gelatinised cassava product. Easy to store and fast to cook, gari is a convenient food well suited for a busy urban lifestyle. The processing of cassava into gari is labour intensive and requires the use of machinery particularly for the grinding of the roots into a mash. Women are responsible for virtually all cassava processing activities in Africa (Ugwu and Ay, 1992).

Because cassava roots can remain unharvested in the ground for 2 to 3 years, they often play a crucial role during civil unrest when displaced populations return to their farms. This has been seen in Uganda, Rwanda, Burundi, Angola, Mozambique and Liberia. In other countries such as Tanzania and Malawi, cassava has been the only source of food during severe droughts.

Nevertheless, a recent survey has indicated that cassava does not simply play a food security role: an average of 40 percent of cassava per field is planted purposely for sale (Nweke, 1996). Recently, various industries have begun using cassava as low cost commodity to substitute expensive imports of starchy cereals.

Cassava production in Africa has increased steadily in the last thirty years and is the only crop, along with yams, to have kept up with the rate of growth of the population. In Nigeria and in Ghana where the increase in production has been spectacular, the use of cassava by local industries and for export is beginning to expand. Biscuit factories are mixing cassava flour and wheat flour in the production of biscuits, starch is being produced industrially, and one factory has successfully switched from the use of molasses to the use of cassava flour in the production of ethanol. Most of the products are consumed within the countries in which they are produced. However, there is a small but growing export trade in dried cassava chips and other industrial products.

Americas

In the Americas cassava is slowly evolving from a traditional staple to a market oriented inexpensive raw material for the manufacture of human, livestock and industrial products that have more elastic markets than fresh cassava. Consumption of fresh cassava is decreasing in urban areas, but the demand for fresh cassava remains high in low-income groups. *Farinha,* a typically Brazilian product, remains a traditional favourite. Fermented starch (sour starch, *polvilho azedo*), with its bread-making properties is finding new uses in the food industry and in urban fast-food outlets.

Small-scale cassava chip and drying plants are being built in Colombia, Brazil, Ecuador and Panama. Small and medium scale starch industries are used by resource poor farmers to generate income. There is some evidence that the scale of the starch industry is increasing, particularly in southern Brazil. The production of sour starch (a naturally fermented product that acquires the ability to rise like wheat dough during baking) is also increasing in Colombia and Brazil due to new product applications with growing demand such as snack foods and bakery products (Hershey and Henry, 1997).

Asia

Since the 1960s, Asian countries, especially Thailand and Indonesia, have grown cassava for processing into value-added export products, offering Asian cassava farmers some stable source of income. Thailand, Asia's largest cassava producer exports nearly 90 percent of its production mainly as chips and to a lesser extent as starch (Maneepun, 1996). In Indonesia, about half of the cassava produced is for local consumption in fresh or dry forms. The rest is used in food and non-food industries or exported as chips. Currently, the cassava industry in these countries is facing shrinking markets for the export of cassava chips and is shifting towards modified starches and other high added-value chemicals. In contrast, the Philippines and Vietnam grow cassava mainly for their domestic market. In the Philippines, cassava is divided almost equally into food, feed and industrial uses. Only 12 percent of the cassava production in Vietnam are consumed as food, mainly as boiled roots. About 60 percent of the production is processed into cassava flour, mainly for the animal feed industry, while the starch industry accounts for 16 percent of the production (Dang Thanh Ha et al., 1996).

China is the fourth largest cassava producer in Asia. In the early 1950s , cassava was mainly used as food; however, in the 1990s industrial uses such as the production of starch and monosodium glutamate constitute the main modes of cassava utilisation (Fang, 1992; Shu-Ren, 1996). Some new industrial products such as ethanol, glucose and fructose are gaining in importance.

Typical cassava foods

It has already been mentioned that cassava can be boiled and consumed as a vegetable. More often than not, the various processing steps described earlier are combined in differing sequences to produce foods typical to specific areas. Sequences may have similar initial steps and then diverge, resulting in very different end products and, conversely, very different processes can lead to similar products. To complicate the matter further, similar products may have different names, while a common name may be applied to different products. There is a myriad of cassava-based food products found all over the world and it would be impossible to mention all of them here. A general review has been compiled by Lancaster *et al.* (1982). Jones (1959) has reviewed the foods made from cassava in Africa. Several authors have reviewed the different uses of cassava foods in individual countries (Favier *et al.,* 1971; Etejere and Bhat, 1985; Nkiere, 1984).

Casabe or 'cassava' bread

Cassava bread is the main staple in the diet of many people in the Amazon Basin and the Caribbean basin, especially in Guyana, Surinam, and Venezuela. It is prepared by reducing cassava into a pulp and spreading the pulp on a hot clay or stone griddle to make a thin and circular cake toasted on both sides. The cake, which may reach 1 m in diameter, is eaten after dipping pieces of it in a stew. Different types of ingredients such as groundnuts can be added to cassava pulp in the making of the cake. The cakes are usually prepared daily for consumption, but they can be sun-dried for several days in order to withstand several months of storage.

Farinha

Cassava pulp is obtained from fresh roots by grating or crushing. The wet pulp is squeezed to remove the excess of water. Various kinds of devices are used for this purpose. The best known and most sophisticated is called *tipiti*; it is a long cylindrical basket constructed by diagonal weaving so that it can be stretched lengthwise at the same time compressing its content. As the basket is stretched, its diameter decreases, the juice is squeezed out and drips along the basket to be collected below if needed. The de-watered pulp is stirred on a hot griddle, taking care to avoid the formation of lumps. The dry granules obtained, known as *farinha seca* or *farinha de mandioca* can be kept for a long time. In Brazil, *farinha* is usually sprinkled on top of other foods to enhance their texture and taste. *Farinha* is produced in small-scale home factories using family labour, or in small-to-medium scale fully mechanised factories with a daily output of 10 to 50 tons of *farinha*. This product is widely commercialised in Brazil where it comes in two grades depending on the particle size of farinha granules: *farinha fina* for a product with very small granules, and *farinha grossa* for a product with larger granules. It should be noted here that, very often, the word farinha is translated as 'flour'; however, given the particle size distribution of farinha, it should be classified as a granular product rather than as flour. A similar product in Trinidad and Tobago is called *farine,* adding to the confusion since this is the French word for flour.

A different type of product known as *farinha d'agua* , found mainly in Northeast Brazil, is made by first soaking peeled or unpeeled cassava roots and allowing them to ferment for 3 to 8 days, or sometimes even longer. During this time fermentation develops and the roots soften. When the roots are removed from the water, the peel is removed if necessary, and a pulp is made, de-watered, and dried like for *farinha seca.* The flour produced in this case has different colour, texture and taste.

Gari

Gari is the most popular cassava product in West Africa. Its preparation is similar to the Brazilian *farinha*. The differences start at the de-watering step. For making *gari*, the wet pulp is placed in cloth bags or jute sacks and weighted with stones to express the water. This de-watering process can take up to a week, or sometimes longer. During this time, a characteristic sour flavour develops due to fermentation occurring in the cassava pulp. The stone-press technique is progressively being replaced by various types of mechanical presses (screw-press, jack-press, and etc..) which shorten the de-watering time. In the mechanised production of *farinha* in Brazil, powerful hydraulic presses are used to de-water cassava pulp in just a few minutes. When a mechanical press is used in West Africa, the cassava root mash is first left to ferment with no pressure applied on the cassava mash. When the fermentation is estimated complete in the *gari* process, the pulp is removed from the bag, pressed, sieved to remove coarse materials, and roasted on a metal pan to make light and crispy granules. The *gari* so obtained is a granular free-flowing meal, white in colour, or yellow if palm oil has been used.

Gari is consumed in a variety of ways (Doku, 1969). Upon adding cold water, the granules swell and soften but retain their individuality; as such, they can be added in a soup or stew. It goes well with cowpea stew. Very hot water can be used to coalesce the individual *gari* granules and form a thick paste. In this form it is called *eba* in Nigeria and can be used just like the cold preparation. Many more variations exist in the utilisation of *gari* as food in West Africa, all mixing the cassava product with other food items to make a complete meal.

Fufu

In Ghana, *fufu* (or *foofoo*) refers to sticky dough prepared from any boiled then pounded starchy food including yam, cocoyam and plantain, as well as cassava. To make *fufu*, cassava roots are first boiled and then pounded in a mortar until a homogenous dough is obtained, which may take about 15 minutes. It is eaten immediately along with a stew made from a variety of meat and vegetables. If left standing, the *fufu* will harden and become unfit for eating.

In Nigeria, *fufu* is the name of a food made from cassava roots soaked for 3 to 5 days, mashed and directly cooked into a dough. However, in Central Africa, *fufu* refers to dough obtained by mixing any type of flour in hot water. One can therefore make cassava *fufu*, corn *fufu,* or sorghum *fufu.* When used alone, however, the term *fufu* refers to the dough made from cassava flour. This flour can be obtained in two ways: sun-drying of fresh cassava whole roots or chips and milling them into flour when dry; or first soaking whole roots in water for 3 to 5 days. Soaking is usually the preferred process if water is in abundance; where water is scarce, cassava flour is made from sun-dried roots. Cassava flour from sun-dried roots is common in East Africa where it is used to make a product similar to the Central African *fufu* but called *ugali*.

Kwanga

Kwanga (or *chickwangue*) is a popular fermented cassava product in Central Africa, particularly in the Congo and in Cameroon where it is called *miondo* and *bobolo*. To make it cassava roots fermented by three days of soaking in water are mashed and steamed. The steamed mash is kneaded into smooth dough which is wrapped in leaves and steamed. After steaming, the wrapped cassava is allowed to cool. The product can be consumed warm or cold. Its shelf life is about 3 to 7 days at room temperature if the wrapping is not open. Otherwise it will dry up and become unfit for eating or it will support microbial growth.

Cassava leaves

In many tropical countries, cassava leaves constitute a highly prized vegetable. Young tender leaves are usually selected, pounded and boiled for 15 to 30 minutes;

various ingredients are then added to taste. In Africa, the highest consumption rates are found in central Africa and in East Africa; however, cassava leaves are widely consumed in several countries of West Africa such as Sierra Leone, Guinea and Liberia. Even though the concentration of cyanogenic glucosides in cassava leaves is 5 to 10 times greater than that of the root parenchyma, there are no reports of toxicity associated with the consumption of cassava leaves. When leaves are processed, their cyanogenic potential is considerably reduced during pounding, and after boiling it is virtually reduced to nil (Bokanga, 1995). A similar phenomenon is observed when cassava roots are ground into a mash, de-watered and heated on a flat hot surface to produce *farinha* in Brazil and *gari* in West Africa. Whereas cassava roots are well recognised as deficient in protein (average 1 percent on fresh weight basis), the leaves contain 7 to 10 percent protein (equivalent to about 30 percent protein on a dry weight basis). The protein content of cassava leaves was determined in 181 varieties and was found to range from 26 to 42 percent (IITA, 1974). Much of this protein is made up of the enzyme linamarase; its activity was found to be about 200 times greater in the leaves than it was in the roots (Bokanga, 1995).

Cassava leaves have a good potential as a source of protein in animal feed. They have the same protein content and the same value as feed as alfalfa, a well-established animal feed in temperate climates. Dried alfalfa foliage is exported to Asia, particularly to Japan, for use as animal feed. In Brazil and in some Asian countries, whole cassava plants (foliage, stems and roots) are shredded and ensiled to make feed for cattle and pigs.

1.4 Secondary and derived product

Fermentation

A recent survey of the modes of utilisation of cassava in Africa has revealed that nearly three out of four cassava-based foods encountered in the survey were fermented products (Westby, 1991). Three types of fermentation are generally distinguished: a submerged fermentation, in which cassava roots, whole or in large pieces, are steeped in water for a period of 3 to 5 days; a mash fermentation, in which a mash is obtained by grating or rasping fresh cassava roots, and the mash is left to ferment in a container for several days; and a low-moisture fermentation whereby peeled cassava roots are heaped together and fungal growth is allowed to develop at the surface of the roots.

Nearly all fermentation relies on the fortuitous presence of microbes on the roots and/or in the water, and on the prevailing favourable conditions for the production of the desired product. In some instances, a small amount of a previous batch is kept and used to inoculate the next, but the fermentation is allowed to follow its natural course with little or no attempt to control it. As a result, the flavour, aroma and texture of the fermented product vary with the season, location, and producer.

The micro-organisms associated with cassava fermentation are mostly lactic acid bacteria (*Lactobacillus plantarum, Streptococcus faecium* and *Leuconostoc mesenteroides*) and spore-forming bacteria such as *Bacillus sp.* (Bokanga, 1989; Nwankwo, et al., 1989; Okafor et al., 1984; Ngaba and Lee, 1979; Abe and Lindsay, 1978). Lactic acid bacteria are mainly responsible for the rapid acidification that characterises cassava fermentation. The *Bacillus sp.* seem to be responsible for inducing the retting of cassava root tissues during the submerged fermentation of whole roots. Other micro-organisms, such as *Corynebacterium sp.,* enterobacteriaceae, yeast and moulds have been reported (Akinrele, 1964; Collard and Levi, 1959), but they are usually present in low numbers and their role is not clearly understood.

It is interesting to note that the micro-organisms found in cassava fermentations are similar to those found in milk fermentation. Some of them may possess unique properties that may be of nutritional or industrial importance, e.g. over-secretion of a specific nutrient or chemical, production of bacteriocins, etc. It is therefore essential that the study of indigenous cassava fermentation should receive more attention than it has in the past.

1.5 Requirements for export

The amount of cassava exported out of Africa and the Americas is negligible, while it is estimated that 27 percent of the Asian cassava production is exported (See Table 8). Thailand accounts for 90 percent of Asian cassava exports and Indonesia about 9 percent. The largest importer of cassava is the European Union which defines four types of cassava products:

i. cassava pellets made by compressing flour or starch;

ii. fresh cassava for human consumption: this category consist of whole and fresh cassava, or peeled and frozen, or sliced in small pieces, packaged in readily marketable form in packages containing less than 28 kg of product;

iii. dried cassava chips

iv. starch

The near-totality of traded cassava (99.6 percent) is in the form of cassava chips (See Table 9). Eight countries (Netherlands, Spain, Belgium, Luxembourg, Portugal, Germany, France and Italy) absorb almost all the cassava entering Europe. In the period 1994-1996, the Netherlands alone accounted for 46 percent of the European cassava imports.

The Thai government has defined the standards of cassava chips for export. Two grades can be distinguished:

A *special grade* refers to dried (but not milled) cassava roots, light in colour, without foreign matter and free from unusual odour; it should have a starch and free sugars content of not less than 72 percent by weight and a moisture content of not more than 13 percent by weight. If sand or fibre is present, they should not exceed 2 percent and 4 percent by weight respectively.

A *first grade* is defined like the special grade except that the maximum permissible level for moisture content is 14 percent by weight.

Table 8. Average annual export of cassava products to the European Union in the period 1994-1996 (in metric tons)

Producing Region	Fresh	Pellets	Chips	Starch	Total
Africa	159	25	21,031	12	21,227
Americas	3,935	5	33,223	821	37,984
Asia	20,925	1,238	3,766,885	8,447	3,797,696
Total	25,019	1,468	3,821,139	9,281	3,856,907

Source: European Commission for Agriculture, 1997

Table 9. Average annual imports of cassava products into the European Community in the period 1994-1996 (in metric tons)

Importing country	Fresh	Pellets	Chips	Starch	Total
Netherlands	1	2,784	1,754,629	1,430	1,758,844
Spain	1,433	0	864,540	7	865,980

Belgium/Luxembourg	7	48	379,629	86	379,770
Portugal	0	1	328,539	23	328,563
Germany	4	3	203,394	1,806	205,207
France	4	293	199,030	3,867	203,194
Italy	2	1	75,745	15	75,763
Ireland	0	0	6,567	0	6,567
United Kingdom	17	1,033	92	1,761	2,903
Denmark	0	0	2,827	10	2,837
Sweden	0	2	0	274	276
Total	1,468	4,165	3,814,992	9,279	3,829,904

Source: European Commission for Agriculture, 1997.

PAGE < TOC PAGE >

INPhO e-mail: inpho@fao.org

INPhO homepage: http://www.fao.org/inpho/

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

PAGE < TOC PAGE >

Organisation: International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria (http://www.cgiar.org/iita/)
Author: Mpoko Bokanga
Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis (Language&Style), Carolin Bothe (HTML transfer)

CHAPTER XII CASSAVA: Post-harvest Operations

2. Post-Production Operations

2.1 Post-harvest biodeterioration

Cassava roots, when left attached to the main stem, can remain in the ground for several months without becoming inedible; farmers do often leave cassava plants in the field as a security against drought, famine or other unforeseen food shortage. It is from this property that cassava has earned its name as a 'famine reserve crop'. However, once the roots have been harvested, they start deteriorating within 2 to 3 days, and rapidly become of little value for consumption or industrial applications.

Two types of deterioration are known to occur. The first to appear -- therefrom named 'primary deterioration' -- consists of physiological changes characterised by an internal root discoloration called vascular streaking or vascular discoloration

(Averre, 1967). It is displayed as blue-black or brownish occlusions and chemical deposits. The time to onset of primary deterioration and the rate at which it progresses, the intensity, pattern and distribution of the discoloration varies between cultivars and roots of the same plant. Some varieties deteriorate so fast they become inedible 24 hours after harvest (Booth, 1976) while others have been reported to stand for 7 to 11 days at room temperature without any sign of discoloration (Montaldo, 1973). From a biochemical point of view, primary deterioration of cassava roots is associated with a conversion of some of the starch to sugars (Booth *et al* 1976), an accumulation of cyanogenic glucosides, a decrease in linamarase activity (Kojima *et al.* 1983), and the onset of a number of enzymatic reactions leading to the accumulation of coloured compounds (Wheatley and Schwabe, 1985).

There is a strong association between the onset of primary deterioration and the occurrence of various forms of mechanical damage. Due to the nature of harvesting and handling operations, mechanical damage is unavoidable; cutting the root off the plant creates a wound; digging utensils may cut or scrap the roots. Breaking off of the root tips and bruising do occur during transportation and handling. Wounds and bruises are the triggers of primary deterioration. Booth (1976) found that primary deterioration was essentially a wound response being initiated near the region of mechanical damage; unlike in other storage organs (e.g. sweet potato), the response is not localised at the surface, but spreads down the root. Wounds and bruises also constitute points of entry for micro-organisms leading to the second stage of cassava root spoilage, known as "secondary deterioration".

Secondary deterioration is induced by micro-organisms that cause rotting. Two types of rot have been identified. Under aerobic conditions, fungi cause a dry rot which results in discoloration and a slight rise in acidity; under anaerobic conditions, bacterial activity (mainly due to *Bacillus* sp.) predominates, giving rise to rapid development of acidity (Ingram and Humphries, 1972). Most of these organisms behave as wound pathogens and infect roots through the sites of injury, and this usually occurs after primary deterioration has set in, and the roots have already lost their appeal to consumers.

2.2 Harvesting

Cassava roots can be harvested at any time of the year. Some farmers harvest as early as six months after planting while others may leave the crop for 18 to 24 months. The food quality of roots, particularly the starch content, increases with time up to an optimal period of 12 to 15 months after planting, after which there is a loss of quality, mainly due to increased lignification. During the dry season, cassava usually drops its leaves. At the onset of rains, a dramatic shift in root quality takes place, probably due to a remobilization of starch towards new leaf formation: the mealy texture of boiled cassava root is often lost, and roots can no longer be used for this purpose.

Harvesting cassava roots is usually done by hand; it is easy if the soil are sandy or during the rainy season. In heavier soils or during the dry season, harvesting usually requires digging around the roots to free them and lifting the plant. To facilitate lifting, the plant is usually cut down about 30 to 50 cm above ground. The protruding stem is used to lift the roots out of the ground. While lifting, care should be taken not to break the roots, as this will lead to losses if broken roots are not retrieved from the soil and to contamination that may evolve into spoilage.

After clearing the land, harvesting is the most labour-intensive operation, and agricultural engineers have sought to mechanise it. Mechanical harvesting of cassava is difficult because of the non-uniform geometry of the roots in the ground. Nevertheless a few cassava harvesters have been designed and some are in operation, mostly by large-scale farmers. The cost of mechanical harvesting is too high for resource-pour farmers.

Young leaves and shoots of cassava are also harvested to be consumed as vegetables and may be as important as roots for generating cash income. Excessive harvesting of the leaves can have a negative effect on the yield of roots. However, it has been shown in D.R. Congo where cassava leaves are extensively commercialised, an optimal leaf harvesting schedule of once every one or two months will result in higher overall returns for the farmer (Lutaladio and Ezumah, 1981).

2.2.1 Methods

The Amerindians, who first cultivated cassava, also devised numerous processing techniques not only to increase the palatability of cassava and to extend its shelf life, but also to decrease its cyanogenic potential. Today, a great diversity of processing methods are found in the various parts of the world where cassava is consumed (Lancaster *et al.*,1982). They consist of combinations of the primary processing steps described below.

Peeling

The first step in processing cassava roots is often to remove the peel; this result in a great reduction the cyanogenic potential of the raw material, because the peel represents about 15 percent of the weight of the root, and its cyanogen content is usually 5 to 10 times greater than that of the root parenchyma. However, the peel also contains large amounts of the enzyme linamarase which is important in the detoxification of cassava during processing. For instance, grinding cassava roots without removing the peel, as is done in the manufacture of the Brazilian farinha, ensures an almost total elimination of cyanogens from cassava.

Peeling is usually done by hand using a knife; the process is slow and labour-intensive, averaging 25 kg per man-hour, but it gives the best results. The Post-harvest Engineering Unit of IITA has developed a cassava peeling tool that is simple, can be fabricated locally and gives minimum peeling losses (See Figure 4a). Mechanical peelers are generally wasteful and with low efficiency. All solutions, including chemical ones that have been developed so far have proved rather impractical. For several years more, peeling cassava will remain as a source of employment and income for rural dwellers, particularly if cassava-based agro-industries develop around cassava farms.

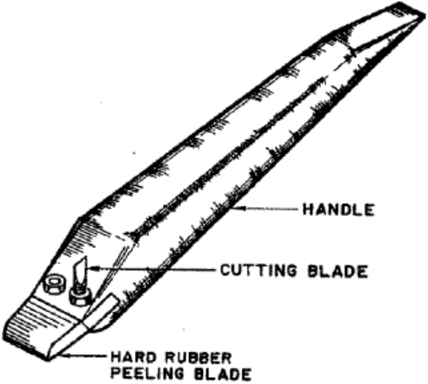


Figure 4a: Cassava peeling tool

Boiling

Cassava is often consumed as a vegetable after boiling for 15 to 45 minutes. Some cassava varieties give a soft, mealy and easy to mash boiled roots. In some parts of

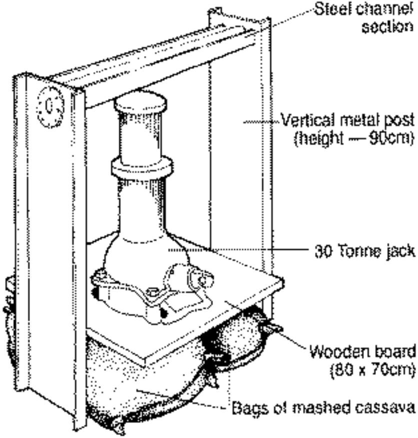
Africa, after boiling, the roots from these types of varieties are pounded into a smooth paste called *fufu*. Other varieties give roots which when boiled remain hard and are waxy; these cannot be pounded into *fufu*. IITA and several African countries have breeding programs to develop the mealy-type cassava varieties. Wherever boiled cassava is consumed, mealiness is the main quality characteristic.

Size reduction: chipping and grating

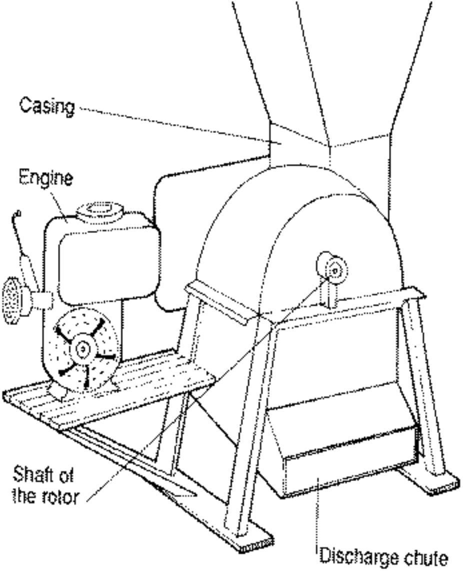
The size of cassava roots is usually too large to process and is usually reduced prior to further processing. At the home level, cassava roots are chipped manually using a knife. This process is slow and produces large and irregular chips that take 3 to 7 days to dry and impart a sour and musty taste, actually preferred by some consumers, to the food made from the dry chips. Mechanical chippers have the advantage of producing smaller and uniform chips that dry rapidly. The drying rate depends on the geometry of the chips and the amount of chips per unit of drying surface. Flat chips tend to stick to each other and reduce the flow of removal of moisture between chips that are stuck together. IITA has designed a low-cost chipper that produces 'finger' chips of about 5mm thickness and a length depending on the size of the cassava roots (IITA, 1996). These chips can dry after 6 to 8 hours of exposure to the sun. When manually operated, the chipper has a capacity of 60-70 kg/hr; but an electric, gasoline or diesel engine can power it with a capacity of 1000kg/hr.

The initial step of several processes for the preparation of foods from cassava is pulping, either by grating or by crushing freshly harvested cassava roots. Examples of foods prepared in this fashion are *gari* in Nigeria, *farinha de mandioca* in Brazil, *cassava bread* in various countries of Latin America and the Caribbean islands (Lancaster *et al.,* 1982). Cassava starch extraction is also carried on after pulping. The pulping process results in the disintegration of cassava tissues, which favours the contact between linamarase and the cyanogenic glucosides. Processes that begin with pulping usually result in the greatest detoxification of the final product. This is the case of the farinha and gari processes, and of the starch extraction process. Once the pulp is obtained, it is usually squeezed to remove the juice. The remaining cake is further processed into food. The juice is discarded, or in some instances, it is used to prepare sauces or beverages (Lancaster *et al.,* 1982). To make starch, the pulp is extensively washed with water to separate the starch granules from the soluble component of the pulp.

Pulping is the first step in the preparation of gari and *attiéké* (West Africa), farinha (Brazil, Caribbean). In Nigeria, the process of grating cassava has been widely mechanised; there are many types of grating machines to choose from. IITA has also developed a grating machine which can be manually operated or equipped with an engine (See Figure 5). The manual grater has a capacity of about 30 kg/hr, while the motorised grater has a capacity of 800 kg/hr. Young roots are usually easier to process, while roots from plants that are more than 18 months old require a longer time to grate because they are generally more fibrous and oppose a greater resistance to the grating process (IITA, 1996).



Hydraulic jack press


Casing
Engine
Shaft of
the rotor
Discharge chute

A typical cassava grater

Figure 5. Equipment used in simple cassava processing

Pressing

After grating cassava, the next processing step is generally pressing the grated pulp to reduce its moisture content. The Amerindians who have been processing cassava for two millennia developed an ingenious press shaped like a long thin basket-weave tube called ´*tipiti*'. The tipiti would be filled with cassava mash, hung on a branch of a tree and stretched from the bottom; its volume would reduce and water would be squeezed out of the mash. In Africa, people used heavy stone placed on top of bags or baskets filled with cassava mash. More recently, screw presses and jack presses (See Figure 5) are used for greater efficiency and speed. In Brazil where grating and pressing cassava have been industrialised, hydraulic presses providing pressures of up to 25 kg/cm^2 are quite common. The moisture content of the mash is reduced from 60-70 percent to about 50 percent. The pressing time can be as short as 15 minutes with the hydraulic press or as long as 4 days or more when stones are relied upon.

The cake obtained after pressing needs to be broken down into granules. This can be done manually or mechanically by passing it again in a grating machine. The powdery granules obtained can then be further processed into the desired products.

2.2.2 Special requirements

Cyanogenesis and safety issues

The single most important constraint in the expansion of cassava utilisation is its association with cyanide. It is essential that this association be well understood for the promotion of the crop.

Cyanogenesis, the ability of plants to produce, under some circumstances, the toxic hydrogen cyanide (HCN), exists in over 2000 plant species belonging to more than 100 families. In all species so far examined, HCN is never produced and stored at any stage of plant growth. The plants produce complex compounds, mainly glucosides, but in some case lipids, which may break down to produce HCN. Those compounds are therefore known as cyanogenic compounds. Plants also produce enzymes that break down the cyanogenic compounds but they are both always stored separately inside plant cells. It is only when the plant is damaged, and the structural integrity of the plant cells is destroyed that the enzyme acts on the cyanogenic compounds to produce cyanide.

Cassava produces two cyanogenic glucosides, linamarin and lotaustralin, in about 10 to 1 ratio. The amino acids valine and isoleucine are the precursors used in the synthesis of linamarin and lotaustralin respectively. The metabolic pathway for converting valine to linamarin has been elucidated by Koch *et al.* (1992).

In cassava plant cells, the cyanogenic glucosides are stored inside the vacuoles in the cytoplasm while the enzyme capable of degrading them is located in the cell wall outside the cytoplasm (Mpkong et al, 1991). Therefore, in intact cells the breakdown of cyanogenic glucosides would not occur. When cassava tissues are bruised and the cellular structures are disrupted, linamarin and lotaustralin come in contact with linamarase and are degraded.

The breakdown of linamarin leads to the formation of acetone cyanohydrin and glucose (Figure 3). At pH above 5, the acetone cyanohydrin will spontaneously break down into acetone and HCN. This breakdown may also be catalysed by the enzyme hydroxynitrile lyase (HNL) which is also present in cassava. Once HCN is produced, it will dissipate in the air (since its boiling temperature is 25.7^{o}C). In damaged plant tissues, which includes processed roots and leaves, it is possible to find non-hydrolysed cyanogenic glucosides, cyanohydrins and traces of HCN. The term cyanogen refers to any of these three compounds.

Old analytical methods for quantifying cyanogens found in the literature often have the shortcoming that they do not achieve complete hydrolysis of cyanogenic glucosides, and therefore, under-estimate. A breakthrough was achieved with the method developed by Cooke (1978). In this method, all the cyanogens are extracted from the sample under conditions that stabilise them, and are quantitatively converted to cyanide ions that are specifically measured by a modified Epstein reaction. The entity measured in this fashion is termed "total cyanogen content". Modifications of the Cooke's method (O'Brien *et al*., 1990; Essers *et al*., 1993) have now made it possible to distinctively quantify hydrocyanic acid, cyanohydrins and cyanogenic glucosides.

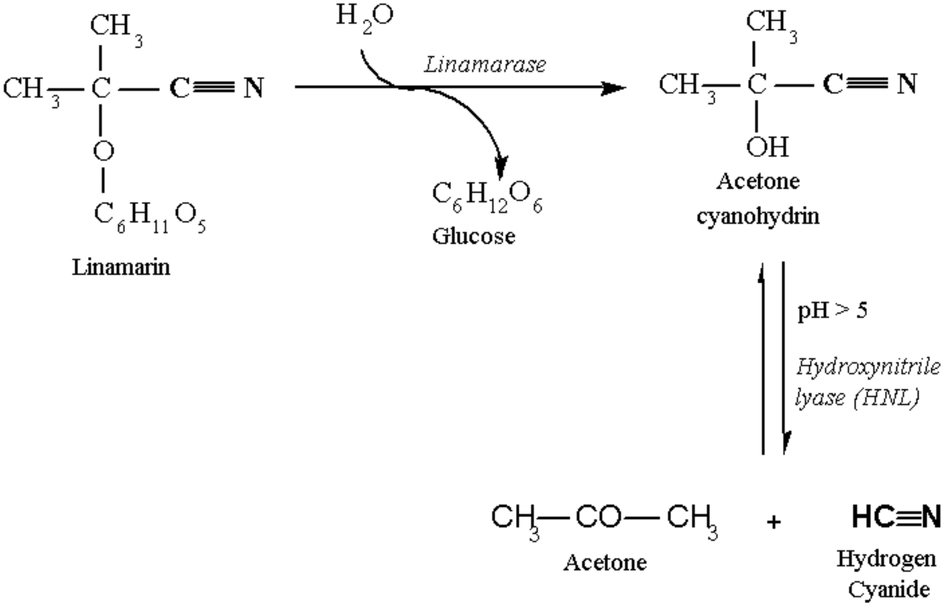

CH3
CH3 — C — C≡N
O
C6H11O5
Linamarin
H2O
Linamarase
C6H12O6
Glucose
CH3
CH3 — C — C≡N
OH
Acetone
cyanohydrin
pH > 5
Hydroxynitrile
lyase (HNL)
CH3 — CO — CH3
Acetone
+
HC≡N
Hydrogen
Cyanide

Figure 3. Enzymatic hydrolysis of linamarin

The term "free cyanide" is used by some authors to refer to hydrocyanic acid and by others to the sum of hydrocyanic acid and cyanohydrins. Some authors use the term "bound cyanide" to refer to cyanogenic glucosides, while others may use it to refer to hydrocyanic acid bound to albumin and other blood proteins as part of *in vivo* cyanide detoxification processes. In the case of total cyanogen content defined above, what this value represent is the maximum amount of HCN that could be obtained from a sample. It therefore represents the CYANOGENIC POTENTIAL (sometimes abbreviated as CNP) of the sample and is usually expressed as mg HCN-equivalent per 100 g, or per kg of sample, taking care to specify whether the value is expressed on fresh or dry weight basis. Because of its simplicity, safety and low cost of reagents used, the method proposed by Essers *et al*. (1993) is recommended.

Cooke (1978) has studied the stability of the cyanohydrin. He found that at 30C and pH 6 it had a half-life of about 30 minutes, and that alkaline pH favoured its dissociation, while acid pH favoured its stability. This is important for the quantification of cyanogens and for the interpretation of cyanogen content of cassava reported in the literature.

Cyanogenic glucosides are not uniformly distributed in the various tissues of cassava plants. The largest concentration is usually found in the peel's cortex, and the lowest in the central pith; the leaves often contain the next highest concentration (De Bruijn, 1971). Younger tissues contain more total cyanide than older ones. In the root, the section closest to the stem (proximal) contains more total cyanide than the middle and distal sections; there is a shallow longitudinal gradient from the proximal to the distal end. From the peel side of the central pith to the centre of the root, the cyanogenic glucosides gradient is more pronounced; the concentration of cyanogenic glucosides is greatest in the outermost 2-3 mm layer and drops sharply towards the centre (Kojima *et al.,* 1983).

Among 67 varieties analysed by de Bruijn (1971), the cyanogenic potential varied from 31 to 630 mg/kg in the root (fresh weight) and from 540 to 1450 mg/kg in the leaves (fresh weight). Similar ranges of cyanogenic potential were found in larger collections of varieties at the International Institute of Tropical Agriculture (IITA) in Nigeria (851 genotypes) and at the Centro Internacional de Agricultura Tropical (CIAT) in Colombia (560 genotypes) (Bokanga, 1994). No correlation was found between the total cyanogenic potentials of roots and leaves. Recent and old investigations have also confirmed this lack of correlation (Bokanga, 1994; Cooke *et al.,* 1978a).

Cassava plants are arbitrarily classified into low- and high-cyanide varieties depending on the cyanogen content of their roots: low-cyanide varieties having roots with less than 100mg HCN-equivalent per kg (fresh weight), and the roots of high-cyanide varieties being above that figure (Hahn and Keyser, 1985). This is not unrelated to the toxicity classification proposed by Bolhuis (1954) in which cassava roots containing up to 50 mg HCN-equivalent per kg are considered innocuous, 50 to 100 mg HCN-equivalent per kg are considered moderately poisonous, and above 100 mg HCN-equivalent are considered dangerously poisonous. The scientific bases for these classifications have never been explained and required more investigation.

The organoleptic descriptors 'sweet' and 'bitter' are often used to characterise cassava varieties. Although earlier reports have associated bitter/sweet varieties with high/low levels of cyanogenic glucosides (Bolhuis, 1954), a cause-effect relationship has not been established (Coursey, 1973; Pereira *et al.,* 1981). A bitter compound other than the cyanogenic glucosides has been isolated (King and Bradbury, 1996). Nevertheless, recent surveys in Africa have shown that farmers associate bitterness of cassava roots with toxicity (Chiwona-Karltun, in press).

Cassava consumption and health

Reported toxic effects of cassava are relatively rare in comparison with its wide use as a staple. A comprehensive review on this topic has been published (Bokanga et al., 1994). High and continuous consumption of cassava has been associated with various diseases and nutritional disorders: tropical ataxic neuropathy (Osuntokun, 1972), goitre and cretinism (Ermans *et al.,* 1983), spastic paraparesis (Mozambique Ministry of Health, 1984; Cliff *et al.,* 1985) or konzo (Howlett et al., 1990). Contrary to the terminology used in earlier publications, there is no cyanide (HCN) of importance in cassava products. These contain variable amounts of cyanogenic glucosides and cyanohydrins. Upon consumption, cyanohydrins can readily decompose into cyanide, but cyanogenic glucosides are partly excreted unchanged in the urine. The cyanide produced is rapidly converted to thiocyanate by the enzyme rhodanese, which is widely distributed in the human body, with the highest concentration being in the liver and kidneys (Auriga and Koj, 1975). Thiocyanate has a known goitrogenic effect: it interferes with the ability of the body to use a limited supply of dietary iodine. However, a high thiocyanate load does not show a goitrogenic effect if the dietary iodine intake is adequate (Delange et al., 1994). Therefore, nutritionists should be aware of the potential goitrogenic effect of cassava in populations in tropical countries with marginal iodine supply and with cassava processing methods that are not efficient in reducing the cyanogen content of cassava food products.

There is increasing evidence to link prolonged consumption of insufficiently processed cassava with a newly described disease named *konzo* (Howlett, 1994; Tylleskar, 1994). Konzo is a paralytic disease (previously known as endemic spastic paraparesis) of abrupt onset appearing in very poor rural communities whose diets almost exclusively consist of bitter cassava roots. According to Tylleskar (1994), there are three prerequisites for the occurrence of konzo; a farming system dominated by bitter cassava, insufficient cassava processing that leaves high residual levels of cyanogens in cassava foods, and a protein deficient diet. Populations growing bitter cassava usually know how to process cassava into safe products (Dufour, 1994), and meeting one's protein requirements is a major priority in all communities. This explains why the occurrence of konzo is so rare and tends to be associated with agroecological disasters such as severe droughts (Howlett et al., 1990), with civil strife (Cliff, 1994) and with economic disturbances (Banea et al., 1992). It should also be emphasised that for millions of consumers, well-processed cassava is a staple food with no associated negative effects.

2.3 Transportation

The first post-harvest task is transportation from the site of production and harvest to the site of processing and utilisation. Tshiunza et al. (1997) estimated that, on average, 70 person-days are needed to carry the harvest from one hectare of land (about 12 tons) over a distance of 1.5 km. The study which covered the six major African cassava producing countries (Cote d'Ivoire, D.R. Congo, Ghana, Nigeria and Tanzania) revealed that 85 percent of the farm output is carried directly to farmers' homes, 10 percent directly to market places and 5 percent to processing places. Transportation from field to home is by way of motor vehicle (15 percent), bicycles (9 percent), carts (6 percent), but mostly by head-load or back-load (70 percent). Women represent 81 percent of people involved in cassava transportation; they carry cassava to all destinations, while men's transportation is almost exclusively directed to the home (Nweke et al., in press). Harvesting and transportation are the most labour-intensive activities in cassava production; together they account for about 50 percent of labour needs for cassava production.

2.5 Drying

Reducing their moisture to a point where all physiological reactions and microbial growth are inhibited can tremendously increase the short shelf-life of cassava roots. In cassava, this point is at 14 percent moisture content, corresponding to a water activity of 0.70. The removal of moisture from cassava roots can be accomplished either by drying in the sun or in an oven. The most common method of drying cassava is sun-drying; moisture content is usually brought down to 8-12 percent. Cassava chips or granules from a grater are spread on a drying surface exposed to sunrays. The more chips on a drying surface, the slower the drying rate will be. Thin chips dry faster than thicker ones. It should be noted that the quality of the chips (e.g. starch content, white colour) is higher if the drying time is short. However, the cyanogenic potential of cassava decreases when the drying time is longer. Therefore, drying parameters that affect the drying rate, especially the loading rate (weight of drying material per unit area of drying surface), are important in determining the residual cyanogen content of the dried cassava.

2.8 Storage systems for cassava

The high perishability of cassava roots has prompted cassava consuming populations to develop storage schemes that alleviate the problem. There are reports that, 300 years ago, Amazonian Indians successfully stored fresh cassava roots by burying them in the soil, and that, in Mauritius 250 years ago, fresh cassava roots were stored in straw-lined trenches for periods of up to 12 months (Booth and Coursey, 1974). Inspired by these reports, researchers CIAT developed a clamp storage system similar in design to the European potato clamp (Cock, 1985; Richard and Coursey, 1981).

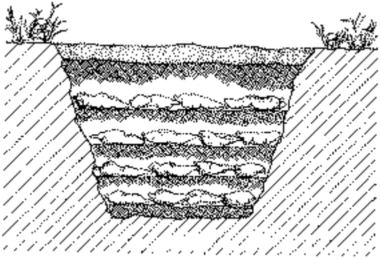
In this system, a conical pile of 300-500 kg of fresh cassava roots is seated on a circular bed of straw and covered with more straw. The whole unit is covered with soil to a thickness of 10 - 15 cm, the soil being dug from around the clamp so as to form a drainage ditch. With this storage system, acceptable levels of loss (0 - 20 percent) were achieved for periods of up to 2 months.

It was noticed during this storage time that bruised or otherwise injured roots tend to undergo a wound-healing response that prevent vascular discoloration or reversed it. This "curing" was correlated with a resistance to discoloration by application of exogenous scopoletin (Wheatley and Schwabe, 1985).

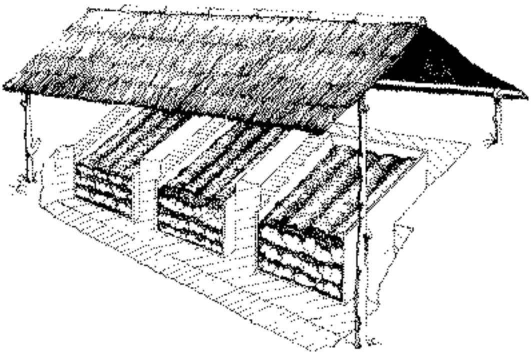
However, clamp storage performs less well during the hot season. The temperature inside the clamp easily reaches 40^{o}C, and heavy losses result even after 1 month of storage (Booth and Coursey, 1974). It has been reported by Marriott *et al.* (1979) that pruning of cassava plants by removing the top of the plant and leaving a short (20 cm) leafless stem 2 to 3 weeks before harvest resulted in roots resistant to primary deterioration even if the roots are severely damaged. These authors have put forth that this resistance was suggestive of a control mechanism for vascular streaking dependent on a factor (or factors) produced in the leaves and translocated to the roots. In accordance with this hypothesis are the findings of Wheatley and

Schwabe (1985) that pruning reduces scopoletin accumulation in the roots but not the response to exogenous scopoletin.

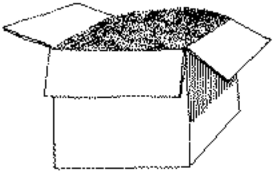
The clamp storage system is not compatible with transportation. To circumvent this, storage in boxes was designed (See Figure 4). Cassava roots are packed in boxes containing adsorbent material such as sawdust (Rickard and Coursey, 1981). The relative humidity inside the box is critical for a successful storage: too high, deterioration due to bacteria and fungi rapidly sets in; too low, vascular deterioration is not prevented.

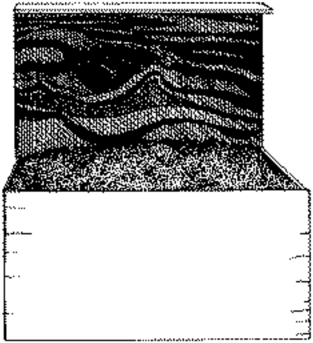


Cassava tubers stored in a trench, covered with soil



Fully filled trenches under a protective shed





Three types of containers used for storing cassava tubers in sawdust

Figure 4. Storage systems for fresh cassava roots.

Packing cassava roots in polyethylene bags was tried and shown to preserve the roots for about 2 months (Cock, 1985). However, complete loss of the stored roots occurred as a result of microbial deterioration. Treating the roots with fungicides retarded the onset of spoilage (Rickard and Coursey, 1981).

The deterioration of cassava can be greatly reduced by cold storage. When kept below 4^{o}C, cassava roots do not show internal discoloration. They still, however, remain susceptible to spoilage by fungi (Rickard and Coursey, 1981). The same authors report that cassava roots could be kept satisfactorily under deep-freeze conditions but that changes in texture occurred in stored samples. Deep freezing of cassava has received little attention from researchers, probably due to the rationale that high-cost storage methods were not suitable for a low-cost commodity such as cassava.

The storage of processed cassava products presents fewer problems than the storage of fresh roots, especially when these products have low moisture content. The major causes of losses are insect pests and fungi (Ingram and Humphries, 1972). A survey of cassava chips processing areas of Benin, Ghana and Nigeria has indicated that the most common fungi were *Rhizopus sp.* (47.5 percent of total samples) and *Aspergillus sp.* (29.6 percent) (IITA, 1996). Fungi proliferate when the moisture content of cassava chips exceeds 14 percent. A large majority of the samples in all three countries had moisture content below the critical moisture level.

The Environmentally Sound Cassava Plant Protection (ESCaPP) project of the IITA has determined that the main insect feeding on dry cassava chips in Benin Republic was *Dinoderus sp.* (Saizonou, 1996). Other insects of importance belong to the species *Carpophilus sp., Araecerus fasciculatus* and *Rhizopertha dominica.* Recently, the large grain borer, *Prostephanus truncatus* , a storage pest of maize, has been found infesting cassava chips in storage particularly during the rainy season. Infestation by all insects is heavier in the rainy season than in the dry season, is more prevalent in the humid zone than in the savannas, and is found more in large chips than in smaller ones (Dossou, 1996). Maximum infestation was found after 6 to 8 months in storage, at which time chips would fall into dust when squeezed.

PAGE < TOC PAGE >

INPhO e-mail: inpho@fao.org
INPhO homepage: http://www.fao.org/inpho/