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CASSAVA

Processing and Storage

Proceedings of an Interdisciplinary Workshop, Pattaya, Thailand, 17-19 April 1974

Editors: E.V. Araullo
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Technology of Cassava Chips and Pellets Processing in Thailand

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Abstract Thailand ranks ninth in the world as a producer of cassava roots and is the world's largest exporter of cassava products. This is due to the fact that Thailand does not use cassava as an important part of the staple diet but exports most of the crop. However, many objections are raised about the utilization of cassava chips and pellets from Thailand. Sometimes the drying periods of chips are very short and the moisture content is rarely reduced below 19%. Sand and waste products are added to the chips to minimize the drying time and make the process economically viable. This high moisture content constitutes a favourable medium for the growth of bacteria and mould.

In general, the main criticisms of Thai cassava pellets from European customers are: minimum starch content is not achieved; much sand and crude cellulose are present; bacteria and mould content are high; and pellets are of friable consistency.

Further study is needed in the processing of cassava chips and pellets. Optimum conditions for the conventional sun-drying of sliced or chipped cassava need to be evaluated. The influence of size of cassava chips on the duration of drying is also an important variable. The use of black body or solar reflecting paint offer the possibility of achieving the drying in a shorter time. Concerning the pelletizing of dried cassava chips, research is necessary to improve the quality of native cassava pellets. The preheating of dried cassava chips with steam, and also the cooling of cassava pellets after pressing, are two main factors to be considered.

Résumé La Thaïlande occupe le neuvième rang dans le monde comme producteur du manioc mais se classe comme étant le plus grand exportateur mondial des produits de cette céréale. Ceci est dû au fait que la Thaïlande n'utilise pas le manioc comme nourriture de base, mais exporte presque toute sa récolte.

Cependant, de nombreuses objections se soulèvent en ce qui a trait à l'utilisation des copeaux et des pellets de manioc de provenance thaï. Il arrive parfois que les périodes de séchage sont de très courte durée et que la teneur en humidité est rarement réduite en bas de 19%. Du sable et des produits de déchets sont ajoutés aux copeaux pour en minimiser le temps de séchage et rendre le procédé économiquement rentable. Cette teneur élevée en humidité constitue un milieu favorable pour la croissance des bactéries et des moisissures.

Généralement, les principales critiques faites sur les pellets de manioc thaï par les consommateurs européens sont: l'insuffisance dans la teneur minimale en amidon; présence de trop de sable et de cellulose; nombre élevé de bactéries et de moisissures; consistance friable.

Des études ultérieures s'avèrent nécessaires pour améliorer le processus de fabrication des copeaux et des pellets de manioc. Il faudrait également évaluer les conditions optimales du séchage conventionnel par le soleil des morceaux de manioc coupés en tranches ou en dés, étant donné l'influence de la grosseur des copeaux de manioc sur la durée de séchage. L'utilisation du corps noir ou des peintures réfléchissantes offre la possibilité d'accomplir le séchage pendant un temps plus court. En ce qui a trait à la pelletisation des copeaux de manioc séché, il est nécessaire de procéder à une étude conduisant à l'amélioration de la qualité des pellets natifs. Le préchauffage par la vapeur des copeaux de manioc séché ainsi que le refroidissement des pellets après pressage, constituent deux principaux facteurs à considérer.

CASSAVA originated in South America where its tubers have been used through the ages as a basic food. From there it spread to Asia and Africa, the main areas of cultivation being Brazil, Nigeria, Indonesia, Malaysia, Thailand, Philippines, India, Colombia, Ivory Coast, Taiwan, Venezuela, and others. The world production of cassava in 1973 totaled over 90 million metric tons (t), most of which was consumed by people living close to subsistence levels in tropical areas.

Although it is important as a staple food crop, cassava has long been neglected by research workers, both in temperate regions and in the tropics. The significance of the crop in tropical agriculture and its growth potential, especially as animal feed, have recently been widely recognized. In the last decade an increased trade has developed with the impetus of using dried cassava chips and pellets as an animal feed component in place of feed grains. The main users of cassava are West Germany, the Netherlands, and Belgium. This situation has arisen mainly because cassava enters the European Common Market at a highly favourable tariff rate compared to wheat, maize, and barley used in the compounded animal feeds (Nestel 1973). During the last 10 years, the importation of cassava to the countries of the European Economic Community (EEC) has more than tripled, and 80–90% of the world market is supplied by Indonesia and Thailand.

In Thailand, cassava does not form an important part of the staple diet; it was developed as a cash crop in connection with a program of agricultural diversification. Because domestic consumption is so low, Thai producers have to seek export outlets. This has met with some success, particularly in the last 10 years, and Thailand is now the world's largest exporter of cassava chips and pellets (International Trade Centre 1968).

Indonesia is counted among the worlds largest producers of cassava, along with Brazil and Nigeria, but the world major exporter is Thailand. This is due to the fact that in Brazil, Indonesia, and Nigeria cassava is used for human consumption and constitutes an important part of the staple diet. For example, in 1970, Thailand exported some 1.16 million t of cassava products and Indonesia 200,000 t.

Malaysian export of cassava products is confined to starch exported in the form of pearls, flakes, and flour, and is not prepared yet to enter the overseas markets for chips and pellets. Nevertheless, in the Malaysian Government's agricultural program, tapioca was one of the crops selected for consideration as an industrial crop on which an industry could be developed for the production of diversified products such as starch, chips, and pellets for both the local and export markets (Lan 1971).

The prospects for the utilization of cassava products indicate that the animal feed sector appears to be an attractive area for future potential use of cassava, not only in developed countries but also in certain developing countries where incomes have reached the stage where people can afford intensively produced meat (Nestel 1973). The projected demand for cereal grains and their substitutes as energy sources for livestock feeds, is expected to grow globally at a rate approaching 3% per year (FAO 1969). Although a greater part of this growth is expected in the developed countries, a substantial part will take place within the developing countries, and this will represent a promising opportunity for export market development in a number of tropical countries. For example, Taiwan's importation of feed grains has increased from 94,000 t in 1964 to more than 1 million t in 1971. Until recently Japan appears to have relied a great deal on imported maize as its main source of feed energy, and the Japanese buyers now appear to be active in the cassava market (Phillips 1974).

These projections indicate that the growth of future demand for dried cassava roots is closely tied to the development of the compound feed industry and this in turn is related to the growth of the livestock industry. Given the current role and growth potential that appear to exist for the use of cassava, a good quality cassava product is desirable and necessary. Although Thai chips are the most popular, they are generally not well peeled and are brown in colour. Some Dutch users complain about contamination and the high content of moisture and of insoluble ash of Thai chips. Cassava chips from Indonesia, called Java chips, are white, well peeled, washed, and dried, and so some Dutch and Belgian manufacturers exclusively use Java chips (International Trade Center 1968).

Cassava pellets are obtained from dried chips and broken roots by grinding and hardening into a cylindrical shape. At present, pellets are mostly produced in Thailand, the largest supplier of cassava products for feed. However, it is said that their pellets contain some cassava waste that lowers the quality, and they are not solid enough to keep their form for later processing (International Trade Center 1968). In Malaysia there is one plant producing cassava pellets but it is still at the experimental stage (Lai 1971). Cassava pellets produced in Indonesia are considered to be good quality, because they are processed from the better quality Java chips. Indonesia will become a strong competitor with Thailand in cassava pellet production.

Present Situation of Cassava Production in Thailand

Thailand ranks ninth in the world as a producer of cassava roots and is the world's largest exporter of cassava products. The main importers of Thailand's cassava products are the Netherlands, followed by West Germany, Belgium, and Italy, all members of the EEC, buying mainly cassava pellets for livestock feed.

The major cassava growing areas are in the eastern part of Thailand (Fig. 1). The main production areas are: Chon Buri, 64,000 ha (160,000 acres); Rayong, 48,000 ha (120,000 acres), and Nakhon Ratchasima, 32,000 ha (80,000 acres) (Harper 1973). It has been reported that in 1970, 6 million t of cassava roots were harvested from a total of 320,000 ha (800,000 acres) for the country as a whole (Anon. 1971).

Cassava starch has been exported to European countries from Thailand for more than 35 yr. After World War II, increased demand came from West Germany where high grain prices prevailed, and subsequently cassava has become attractive to the Belgian and Dutch animal feed industries. Initial shipments of cassava feeds were in the form of tapioca waste (meal) from starch manufacturing. Meal in combination with soybean is an excellent grain substitute in feeds and as such is of special importance to pig farmers. In 1958, with the introduction of cassava chipping machines and hammer mills from Germany, cassava chips were produced directly from roots. Since 1967, the production of pellets has been growing very fast and the demand for chips and meal has declined considerably (Kordilok 1970).

Two major objections have been raised about the utilization of tapioca pellets from Thailand and these concern the nutritional and technological properties of the product. High sand and cellulose content and extensive mould and bacterial growth are often in the product, necessitating radical changes in the planned feed formulation in certain cases, and affecting the nutritional value of the product (Mathot 1972). High meal content in the pellets presents many technical problems, including increasing costs of unloading the seagoing

FIG. 1. Major cassava growing areas in the eastern part of Thailand.

ships and lighters. Also, when the moisture content of the chips is higher than about 17%, the pellets are of a very inferior quality, as they are soft and have an unfavourable weight per volume ratio.

A thorough investigation is recommended into the problems of drying and pelletizing cassava chips to obtain a good product with constant and optimal quality. The purpose of this report is to concentrate on those technical problems encountered during the manufacture of cassava chips and cassava pellets. The ideas and suggestions brought out in this paper will provide building blocks for future research activities and point up areas of research needs.

Harvesting

Root size increases with the age of the cassava plants and normally reaches a peak at about 15 mo, with a slowdown in root production occurring a few months before this time. Thus harvesting is preferable when the plants are about 12 mo old, and in practice growers normally harvest between 10 and 12 mo (Harper 1973). However, under certain subsistence farming conditions, the practical way of dealing with cassava tubers is to leave the plants in the ground until needed, and, once harvested, to process the roots immediately into some form of dried product. This system has many disadvantages, the most important being that large areas of land are occupied by a crop that is already mature, and are thus unavailable for further cropping (Ingram and Humphries 1972). The tubers may increase in size when left for prolonged periods, but they become more fibrous and woody and their starch content declines (Greenstreet and Lambourne 1933; Holleman and Aten 1956; Jones 1959; Grace 1971). The susceptibility to loss in starch content when cassava remains in the ground after it has matured appears to be a disadvantage for starch production, but it could be turned to an advantage when cassava is used for chip and pellet manufacture: a firm and rigid product could be obtained which would be more easily handled. This point should be emphasized by research work in order to know which cassava products are appropriate to which purposes.

Storage of Fresh Cassava

Cassava tubers are extremely perishable after harvest and cannot usually be kept for more than a few days without severe rotting, making them unfit for processing into any useful product. This characteristic of cassava is well known and has long been a problem with regard to storage.

Apart from a combination of physiological and pathological factors, the storage life of any perishable produce can be affected by environmental conditions such as temperature, humidity, and aeration. Deterioration begins with decay of the tissues, accompanied by a dark bluish discolouration or dark streaking of the infected area, or both; streaking often follows the vascular bundles (Ingram and Humphries 1972). The bluish discolouration and vascular streaking in stored tubers are believed to result from an enzymatic reaction (Averre 1967), but this may be associated with penetration of pathogens along the vascular bundles. Numerous studies have shown that the post-harvest pathology of cassava is a complex matter, involving more than a single initial pathogen. The principal bacteria and fungi isolated from fresh cassava include: *Rhizopus* spp. causing a dry rot under aerobic conditions, and *Bacillus* spp. causing a soft rot under anaerobic conditions (Majumder 1955); *Rigidoporus lignosus* (Klotzsch) Imazeki, associated with pre-harvest infection with "white thread" disease (Doku 1969; Affran 1968); *Diplodia manihoti* (Sacc.), causing the most serious market disease (Burton 1970). A number of other pathogens of lesser importance were also isolated: *Fusarium* sp., *Geotrichum candidum, Trichoderma* sp. *Aspergillus niger,* etc. (Burton 1970).

Tubers frequently commence rotting at the point of disattachment from the parent plant; it has been suggested then that tubers should be cut with a stub of the "union" or stem still attached: rapid spread of decay into the tuber is thus prevented (Tracy 1903; Irvine 1969).

The few investigations so far reported on fresh cassava storage have included: natural storage, chemical treatment, and cold storage.

There are a few successful long-term natural storage methods of fresh cassava reported in the literature. One of the best known natural storage techniques is de Reine's method. Layers of cassava tubers are arranged alternately with 7.5-cm layers of earth and the top-most layer is then covered with well-beaten earth 15 cm in depth and built up to a ridge for drainage. Tubers were reported to be fresh after 12 mo storage in this system (Anon. 1944). Different types of storage structure had been tested: dark room in a wooden building; local building (an ordinary room in the building); cellar and trench (Baybay 1922). Under all conditions in these trials, cassava tubers sustained high weight losses after 25 days of storage, from 64.0% in the trench to 92.2% in the local building.

In Thailand, the natural storage of cassava roots is to leave them underground until required. A few processing factories store the cassava tubers in silos or under covered roofs where the roots are heaped for 2–3 days. No chemical treatments or reduced temperature storage are being used. More research is needed to develop an economical natural way of long-term storage of cassava tubers, and preliminary investigations on chemical treatment storage and reduced temperature storage should be begun in preparation for the further increased demand for cassava products in domestic and overseas markets.

Processing of Cassava Chips

The production of cassava chips in Thailand is a relatively simple procedure consisting of slicing or shredding the roots by means of a rotating notched cutting disc or knife blades mounted on a wooden frame equipped with a hopper (Fig. 2). The chips, which are irregular in shape, have to be dried. Sun-drying is applied primarily where the sliced roots are spread out on large concrete surfaces in the open. Drying periods usually require 2–3 days with periodical turning over of the chips until the moisture content reaches 13–15%, which is acceptable to the pellet manufacturers (Fig. 3).

When there is a threat of rain during the drying process, the chips are collected by hand into piles under a small roof.

The dried chips are bagged in jute sacks of 70–80 kg, and stored for 2–3 days in the sheds. These sheds consist of iron roofs and wooden walls. The chips are then sent to the pelletizers, where they are kept for a longer period of time. If chips are not properly dried, bacteria and moulds will develop during storage (Fig. 4).

The recovery rate of chips from roots is about 38–40%. However, the products are considered of inferior quality by some quality-conscious feeding-stuff manufacturers in the Netherlands and Belgium, although many German manufacturers consider them satisfactory (Grace 1971).

To produce white chips of superior quality, it is recommended that the roots be trimmed, peeled, and washed in a manner similar to the processing of cassava flour; otherwise the chips are brown in colour, and have a high content of fibre, sand, and foreign material. The washing of cassava roots before the chipping process will reduce the bacterial content of chips and pellets during the storage.

When adequately dried, chips have good keeping qualities, but if stored too long they are subject to attack by insects and moulds. Moulds that have been identified include *Aspergillus, Mucor, Penicillium,* and *Rhizopus*

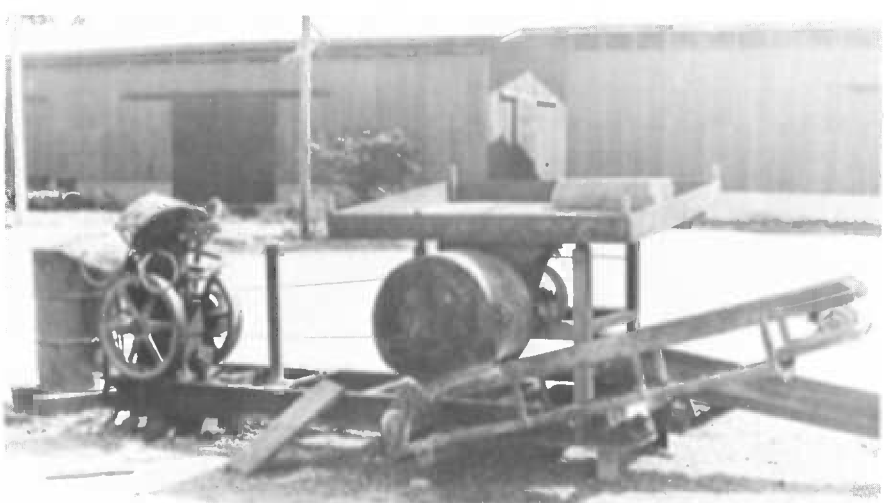

FIG. 2. Thai chipping machine.

FIG. 3. Chips on the drying floor and under shelter for rainy periods.

FIG. 4. Jute sacks containing dried cassava chips.

spp. (Clerk and Caurie 1968; Rawnsley 1969). Cassava chips absorb moisture rapidly from a humid atmosphere and soon reach equilibrium moisture content (Anon. 1952; Kuppuswamy 1961). At 30°C a moisture content of 15.1% was in equilibrium with an atmospheric relative humidity of 70%, which is the accepted upper limit for safe storage (Anon. 1965). The product is usually regarded as stable at a moisture content of 12%. In Thailand, the drying periods are sometimes very short and the moisture content is rarely reduced below 19%. Sand and waste products, such as tapioca fibres, are added to the chips to minimize the drying time and make the process economically viable. It is obvious that with this high moisture content, cassava chips constitute a favourable medium for the growth of bacteria and mould.

Chips are a starting product for making pellets. Great care should be given to the drying process to obtain adequately dried chips. For this purpose, several techniques of drying can be investigated, for example, drying by the principle of "black body," or by using the solar radiation. The possibility of using cascade driers after sun-drying of cassava chips is also an alternative (Mathot 1972). It has been also reported that the chips that are pressed in Thailand to pellets are too large for this purpose. Alternatively, cassava roots can be cut into strips instead of chips, using cutting machines commonly adopted to cut sugarbeets for sugar extraction.

Pelletizing of Dried Cassava Chips

Cassava pellets are obtained from dried chips and broken roots by grinding and forcing into a cylindrical shape. These pellets are less than 1 cm in diameter and about 2 cm in length (Fig. 5).

The process of producing feed pellets can roughly be described as a plastic moulding operation of the extrusion type. Feed ingredients are made up of various compounds such as proteins, acids, sugars, fibres and minerals. These products can be softened (conditioned) by the addition of heat and water. When sufficiently controlled compression is applied to the "conditioned" feed ingredients, they will form a dense mass, shaped to conform to the die against which it is pressed. When the heat and moisture are again withdrawn (dried and cooled), the shaped mass (pellet) retains its shape and density and nutritive value and is of such "toughness" as to withstand moderately rough handling without excessive breakage.

Cassava pelletizing is carried out by two types of firms in Thailand: one is undertaken by German tapioca shippers who work together with Thai cassava exporters, which constitute 25% of exports, and the remaining 75% is processed by Thai factories. Pellets are defined as either "branded" or "native" depending upon whether they are processed by German firms or by Thai factories. Branded pellets are generally considered to be of better quality. Feed industries in the EEC countries claim that native pellets are inferior (soft pellets containing too much meal), and are highly variable and of poor composition (much

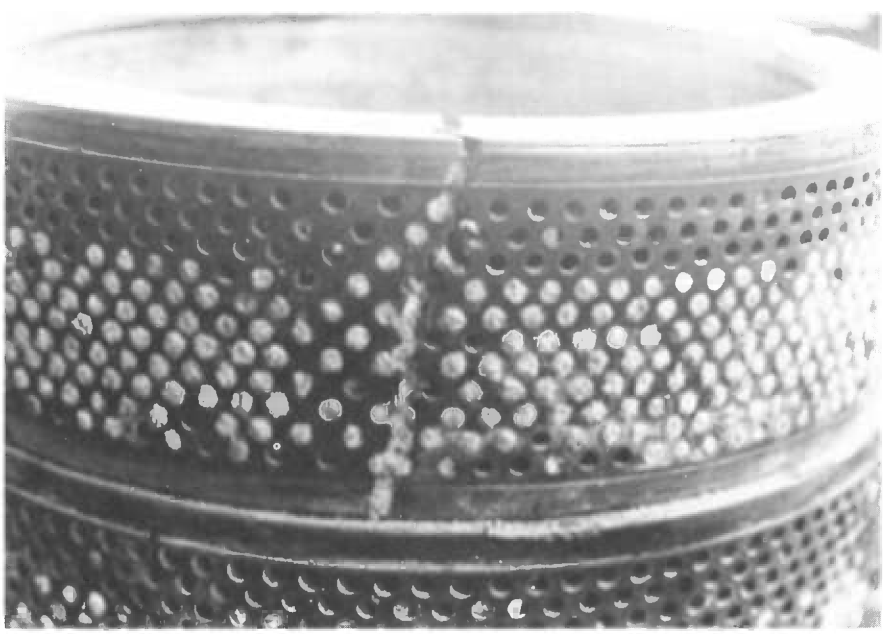

FIG. 5. Broken dies of a presser.

sand and crude cellulose). High moisture content in the final product, providing an excellent medium for bacteria and mould during the storage period, is an additional objection to the native cassava pellets.

In general, the main criticisms of Thai cassava pellets from European customers are that: minimum starch content is not achieved (minimum 62%); maximum sand and foreign matter limits are exceeded (maximum 7% raw cellulose and 3% sand); maximum moisture content is exceeded (maximum 14% moisture); bacteria and mould content are too high; and pellets are of poor, friable consistency. Because of these criticisms, research is needed to improve the quality of native cassava pellets. One approach could be to determine the influence of preheating the cassava chips with steam (70°C) before pressing. This can be expected to produce pellets with strong structure. Another approach could be to adopt cooling of cassava pellets to maximize loss of moisture and thus reduce mould and bacteria standard plate counts.

Marketing of Cassava Products in Thailand

Cassava products are traded in Thailand in a completely free way. No fixed price is established and competition between buyers of the different products is very active.

The fresh cassava roots are sold to driers by the growers on an individual basis. Dried chips are packed in bags and offered to pressers who collect the product from the driers as well.

As already mentioned, branded pellets, which represent 25% of the total pellet export, are manufactured by European exporters and by combinations of European and Thai exporters. These branded pellets are imported into Europe by shippers or by importers who buy from the shippers.

The native pellets are purchased by Thai exporters through agreements with local pressers, but no binding contracts are concluded. Some Thai exporters have their own pelletizers. The native product is sold to European shippers in Bangkok just a short time before it is shipped. Long-term contracts between exporters and importers rarely exist.

It is almost certain that the purchase price of chips will increase in the future because demand is increasing. At the present time coordination between tradesmen is poor. Nevertheless, the shipper provides a service to both small and large pelletizers that neither wish to or are easily able to assume. Large commercial firms are more advantageous than small pelletizers because they can afford higher chip prices and achieve better quality. Thus, it is possible that in the future a greater proportion of pellets will be produced in larger commercial plants.

It is recommended that a study be carried out into the feasibility of grouping native pelletizers in Thailand into cooperatives for better quality control of the products.

Conclusions

The use of cassava as a livestock feed has had a substantial demand during recent years, particularly in the European Economic Community and is expected to increase in the future; it is important then that imported cassava not only be priced competitively, but also be of high quality. It is important that producing countries intensify quality control tests.

Further study is needed in the processing of cassava chips and pellets. Optimum conditions for the conventional sun-drying of sliced or chipped roots need to be evaluated. The influence of size of cassava chips on the duration of drying is also an important variable. The use of "black body" or solar reflecting paint offers the possibility of achieving the drying in a shorter time.

Concerning the pelletizing of dried cassava chips, research is necessary to improve the quality of native cassava pellets. The preheating of dried cassava chips with steam, and also the cooling of cassava pellets after pressing are two main factors to be considered.

Finally, a study should be carried out into the feasibility of grouping native pelletizers in Thailand into cooperatives for better quality control of the products.

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