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Artisanal production of palm oil meets a significant and growing portion of the domestic demand in Cameroon. The traditional technology of pressing palm fruits is laborious and has a low yield of oil. In some areas, service pressing is available using manual Colin expellers, which are aging and no longer imported. Recently, commercial manufacturing of another small-scale expeller, the manual or motorized Caltech, began in the country. A vertical axis version has also been developed. The economic viability of these presses and two alternative screw-operated batch presses used elsewhere in Africa, the UNATA and SODIZI, are compared. Other screw-operated batch presses, hydraulic presses, and phase separation extractors are also discussed.

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# An Economic Analysis of Small-Scale Technologies for Palm Oil Extraction in Cameroon

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## ABSTRACT

Artisanal production of palm oil meets a significant and growing portion of the domestic demand in Cameroon. The traditional technology of pressing palm fruits is laborious and has a low yield of oil. In some areas, service pressing is available using manual Colin expellers, which are aging and no longer imported. Recently, commercial manufacturing of another small-scale expeller, the manual or motorized Caltech, began in the country. A vertical axis version has also been developed. The economic viability of these presses and two alternative screw-operated batch presses used elsewhere in Africa, the UNATA and SODIZI, are compared. Other screw-operated batch presses, hydraulic presses, and phase separation extractors are also discussed.


## The Importance of Artisanal Palm Oil Production

Palm oil comes from the pulp of the fruit of Elaeis guineensis. It comprises over four-fifths of crude edible oil production in Cameroon and is the principal cooking oil in much of West and Central Africa. FAO/WHO estimated that 70% of malnourished children in LDCs just suffer from a shortage of calories, not protein. As a concentrated source of calories, increased consumption of palm oil could help solve this problem. Since crude palm oil is high in carotenes, vitamin A deficiencies that can lead to xeropthalmia are uncommon where this cooking fat is used (Otto 1987). A different kind of oil, palm kernel oil, is derived from the kernel of the fruit, but it is mostly used for non-edible purposes.

Oil palm is indigenous to Cameroon. Much of the semiwild palm harvested in Cameroon is Dura that has spread naturally from old plantations. Fresh fruit bunches (ffb) containing the stalks and fruit of Dura have an oil content of 8.0-12.5% by weight. Dura has a large kernel and relatively small pulp (Asiedu 1986). Not all of the wild oil palm is Dura; other wild varieties have a

similar oil content. Tenera, a hybrid developed in the late 1950s, is cultivated intensively on new plantations. Tenera fruits are larger than Dura, but have small kernels. The oil content of Tenera averages 22.5% of the ffb weight (Spaenhoven 1986). In West Africa, selected Dura typically yields 3.0 t of ffb per ha, compared to 9.0 t for Tenera and 1.0-1.5 t for mixed semiwild stands (APICA/GATE 1983; Hadcock 1984; Moll 1987).

The variety of palm used affects the choice of pressing technology because it affects the profitability of oil extraction. Also, the relative extraction efficiency of different types of presses varies with the ratio of pulp to kernel, which is low for Dura and high for Tenera. Harvesting difficulties are another important reason why farmers are switching from semiwild palms, which are tall and can only be harvested by dangerous climbing. As a dwarf, Tenera can be harvested by using a sickle attached to a long pole.

Semiwild oil palm is a crop that provides supplementary income without taking up much time. Palm yields are less seasonal than many other crops. Little or no cultivation is done except for clearing of brush around the trees and occasional watering in the dry season. Most of the labor is in harvesting and processing of the palm fruits. The trees are long-lived and propagate naturally, but may take 7 years to bear (Onochie 1982).

By contrast, plantations of Tenera require considerable effort in establishment and maintenance in the early years. Tenera begins bearing after 4-5 years, but 10 years are required for maximum production (Moll 1987). As stands age, the number

of bearing trees per ha may fall and the number of bunches per palm declines. The economic life of a plantation is 25-30 years (Tjeng and Olie 1978).

In 1986, Cameroon had 59,384 ha of productive Tenera plantations and over 10% of this area is in smallholdings (FAO Investment Centre/IBRD 1986; Moll 1987). Suitable land is available for expansion of plantations, but high labor turnover and high transportation costs for the perishable fruits limit production. Government policy in Cameroon encourages expansion of oil palm plantations in the forest zone.

Most of the artisanal production comes from semiwild groves. Semiwild palms may cover as much as 385,000 ha of land (Country Report: Cameroon 1984), but less than one-third of this area is harvested due to difficulties in obtaining labor and marketing palm oil (Moll 1987). In fact, the population of wild oil palm has increased during regrowth after slash and burn cultivation because it cannot compete with established broad-leaved trees (MacFarlane, Swetman, and Coursey 1984). In addition, there are 2,000-3,000 ha of Tenera smallholdings that are not tied by contract to large-scale industry, often because of their distance from the mills.

Large-scale industrial production of crude palm oil amounted to 95,000 tonnes, and artisanal production has been estim d at 28,000-32,000 tonnes (FAO Investment Centre/IBRD 1986; Mfoula 1987; Mimba 1987; Moll 1987). Large-scale palm oil mills conventionally operate on double or triple shifts per day. At present, the capacity use rate at large-scale mills in Cameroon

is only 24%. Reasons for this poor capacity use rate include low world market prices, domestic transportation and sales problems, and high production costs for palm fruit and oil. Because large-scale mills in Cameroon cannot compete with Southeast Asian producers, most of the production is sold on the domestic market where government policy pegs the price above the world market level (Hyman submitted).

The artisanal sector offers important advantages in meeting the rural demand. First, rural consumers prefer the sharp taste of local oil with a high FFA content over industrial-quality oil. Second, production costs are low because of the relatively inexpensive source of palm fruits and low equipment costs. Unskilled labor, often from unpaid household sources is the main input. Third, artisanal production has been more stable than industrial-scale production from year to year. Fourth and most importantly, the industrial product often does not reach remote rural areas. When it is available, the industrial product sells for a higher retail price in rural areas than in urban areas because of high transport costs and a lower volume of purchases.

Rapid processing of the fruits is important because their quality can deteriorate rapidly. Yet, the traditional process is slow and industrial-scale mills may face delays and high costs in transport of bulky palm fruits before processing. Consequently, there are advantages to artisanal production near the harvest site using a press that has a rapid throughput.

Per capita household consumption of palm oil was 9.94 kg/year in 1985 and is projected to increase to 10.75 kg/year in

the year 2000 (FAO Investment Centre/IBRD 1986). Total domestic consumption of palm oil has been estimated at 117,000 to 135,000 t in 1986. Projections of demand for the year 2000 range from 146,000 to 238,000 tonnes (CDC 1983; Younoussi 1985; FAO Investment Centre/IBRD 1986; GRET 1986). Under all of the above demand forecasts, new plantings would be needed as the total harvest from existing industrial plantations levels off. Assuming replanting of existing plantations, the total output of palm oil from large mills would only be 1.5% greater in the season 2000-2001 than in 1984-85 (FAO Investment Centre/IBRD 1986).

As a result of the expected shortfall between future supply and demand, per capita consumption would either have to decline or be maintained through imports or expansion of artisanal production. The large unused area of semiwild trees and new smallholder plantations of Tenera could support expanded artisanal production.

The large-scale mills have also had problems with their contract farming programs with smallholders. There is a high rate of drop-out from the programs. The distance between farms and political pressures to expand participation beyond a 25-km radius of the mills made transport costs high for the companies. Moreover, the complementary investments they incurred for equipment, transport, and quality control proved burdensome given the small share of their total raw materials that smallholders comprise. Thus, it has been suggested that companies eliminate contracts with smallholders beyond the economic distance for

transport of palm fruits (FAO Investment Centre/IBRD 1986).

If contract growing arrangements were canceled, it could stimulate the demand for small-scale pressing equipment with low capital costs. Many smallholders with Tenera plantations also have some land with semiwild palm, which could increase the capacity use rate for the presses. However, as long as the contracts are available, many farmers will resist giving up the security these arrangements provide, even if there is a potential for higher income on their own. They may be concerned about the risks of making the capital investment for equipment, supervising labor and maintaining quality control in processing, or difficulties in marketing the product.

The traditional process of palm oil extraction is laborious and yields a low percentage of the oil contained in the fruit. In Cameroon, the traditional process is still used in parts of the Centre-South province the Northwest province, and the Southwest province. It is mainly carried out during part of the dry season, December to February. To the extent that artisans upgrade their technology from the traditional process to simple pressing equipment, rural incomes could be increased, labor drudgery reduced, and consumer benefits boosted from an increased supply of palm oil.

However, most artisanal-scale palm oil producers in Cameroon have access to an old Colin press -- a small, manually operated, expeller. Small farmers who do not have their own presses can purchase pressing services from others in exchange for an in-kind payment of one-fifth of the oil extracted. The farmer also

provides the labor for hand pressing or pays the fuel cost for a motorized press.

The Colin was imported to Cameroon between the 1930s and 1973. As of 1982, approximately 400 Colin expellers remained in Cameroon. Most were over 30 years old and many were in disrepair, leading to poor productivity and frequent downtime (APICA/GATE 1983). Also, replacement parts were no longer available from the distributor (GRET 1986).

In 1972, the Speichim Co. bought out Colin and stopped routine manufacturing of artisanal-scale presses. In 1981, it announced that it would only accept special orders for a modified version, the Speichim 10000, in a lot of 20 or more. However, traders in Cameroon have been unwilling to take the risk of placing that large an order (GRET 1986). Due to the lack of affordable equipment for replacement and expansion, increases in artisanal palm oil production have been limited.

The Association Pour la Promotion des Initiatives Communautaires Africaines (APICA) sought to remedy these problems. APICA is an international NGO with headquarters in Cameroon and activities in various Central African countries. Plan Palmeraies Villageoises (PPV), a program of the Catholic mission supporting the planting of improved palm varieties around Otele in Cameroon, suggested that APICA adapt a motorized Speichim expeller for local manufacture, but the design was patented and production costs were considered too high. The Ministry of Planning recommended establishing a repair service for the old, manual Colins. The Institut Panafricain de

Developpement, urged selection of a press that could be adopted to upgrade the traditional process for palm oil production.

APICA sought ATI support for a project on rehabilitation of existing Colin presses and production of auxiliary equipment such as cooking drums, bunch strippers, and clarifiers. APICA started its own subsidiary for the reconditioning, Outils Pour la Communaute (OPC), and subcontracted for certain parts. In 1984, ATI provided APICA with a three-year grant of U.S. $304,324 for working capital, equipment, and a revolving loan fund.

The original goal of the project was to purchase 75 used Colins for reconditioning and sell at least 68 units consisting of the press and the auxiliary equipment over three years. It was expected that new groups of palm oil producers would be established, each with an average of 20 members. Because it was assumed that the group members would be switching from the traditional method, the estimated benefits were high -- a 25-50% increase in palm oil production with a 50-75% decrease in processing time.

A lease-purchase arrangement was established to finance the sale of 25 extraction units. This plan allows monthly payments over 36-48 months after a 3-month grace period. Group members would leave 25% of the oil extracted from their palm fruits for use of the press. This repayment method is similar to the prevailing arrangement for service pressing, but after the last payment, the borrower receives title to the equipment.

The original design of the project proved unworkable. First, only 12 used Colin presses were available for purchase at

a feasible price because of the incorrect assumption that a large number of these presses were in disrepair and idle. Even though many presses had the wrong parts and maintenance difficulties resulted in downtime, they were still usable much of the time. Also, it took up to 10 months for OPC to obtain imported replacement parts. Second, because of the high cost of repairs in small batches, the lease/purchase price was too expensive for potential buyers. At the same time, world market prices for palm oil declined, causing the large-scale firms to shift more production from exports to the domestic market where prices were higher. This adversely affected prices received by artisanal producers through competition.

Consequently, OPC only received 4 orders for reconditioned, manual Colin presses in the first year, 3 from small groups and 1 from an individual. Some potential buyers expressed an interest in obtaining motorized presses. Recognition of these problems led to a modification of the project. ATI and APICA decided that reconditioning an old press was too expensive and slow relative to production of a new press. Moreover, a simpler, less expensive model with fewer imported components was sought, so the horizontal Caltech was designed. Later, a far cheaper vertical axis Caltech based on a different design principle was developed.

With the shift toward manufacturing and a more realistic view of the effective demand for new presses, the production target was reduced to a total of 35 presses including 9 manual Colins, 12 motorized Colins, 6 manual Caltechs, and 8 motorized

Caltechs. The revised target for auxiliary equipment is 23 sets of the bunch stripper and clarifier. Repair services and motorization also were initiated. After the reorientation, the project became more successful. By the end of 1987, OPC had sold 8 manual Colins, reconditioned 3 more, and reconditioned 1 and converted it to a motorized press. It had sold 38 horizontal Caltechs, and 10 more were in production. Also, 7 vertical Caltechs had been produced. Only 10 clarifiers and 11 bunch strippers had been sold (Perry 1987). Financing played an important role in encouraging sales (Laffitte 1987).

The idea of purchaser groups proved unpopular, particularly in Otele where the market has been largest. This area is dominated by the individualistic Bassa tribe. The traditional property rights of the Bassas limit the access of the young to land and it is difficult to gain cooperation for repair of a group-owned press. Considerable interest in artisanal-scale presses exists in Otele because farmers there cannot sell palm fruits to the parastatal oil mills because the distance is too great. In addition, the PPV program has been made progress in establishing smallholder plantations of improved palm varieties around Otele. Other areas in the Littoral, Center, and South provinces face similar constraints on collective economic activities; however, various women's groups have been successful in the Northwest, Southwest and Western provinces (Moutsi 1987; Egli 1987).

The impacts on palm oil production and labor productivity are less than originally expected because most artisanal

producers in Otele had previously been using a mechanical press rather than the traditional method. However, it also means that displacement of women's activities has been minimal. The principal impacts have been on incomes of the new press owners. In the course of this project, an economic analysis was undertaken to evaluate the merits of these presses compared to alternatives and to help in targeting the market.

## The Traditional Technology

Two types of palm oil are produced by traditional processes, depending on local tastes: soft oil and hard oil. Soft oil has an FFA content of 7-12% (Moll 1987). Hard oil has a sharper taste because its FFA content is usually around 20% and can be as high as 30-50% (MacFarlane, Swetman, and Coursey 1984; Asiedu 1986; Moll 1987).

Figure 1 summarizes the process. There are two main differences in production of the two types of oil. First, the fruits are left to ferment for a longer period of time for hard oil. Second, for soft oil, the cooked fruits are pounded in a wooden mortar with pestle. To obtain hard oil, the fruits are stomped by foot instead and the oil is skimmed off the surface by hand as water is added.

Around Otele, in the Centre-South province, the hard oil process is used, but the fruits are cooked before treading. It has been estimated that it takes 52 person-hours to process 128 kg of stripped fruit in this way from harvesting to bottling, but excluding marketing (APICA 1982). Most farmers in Cameroon using

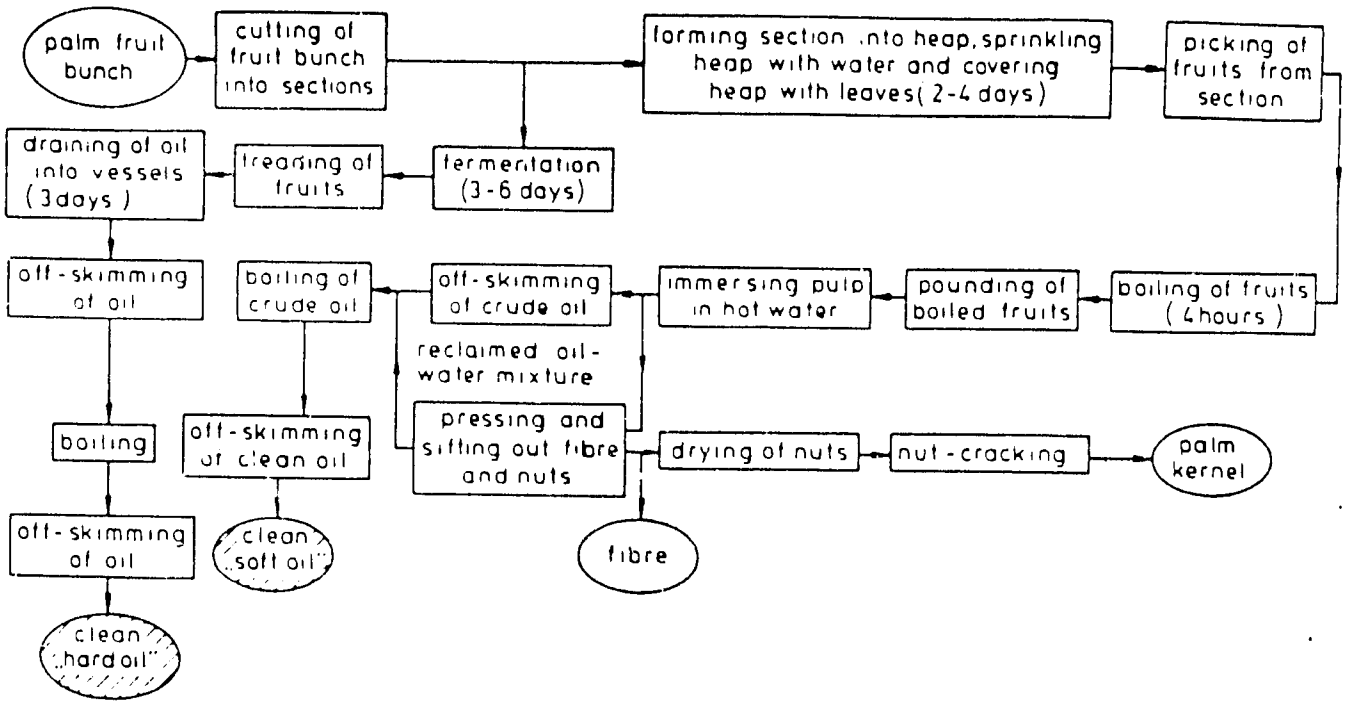


Figure 1. Flowchart for the Traditional Processing of Palm Oil Production

Source: Asiedu 1986.

the traditional process do less than ten production cycles per year (ATI 1984). The only capital cost would be CFA 10,000 for a hollowed-out tree trunk to store the stripped fruits during fermentation (in mid-1987, there were 300 CFA per U.S. dollar).

The extraction rate is the weight of the oil obtained as a percentage of the weight of the ffb (or sometimes, the stripped fruits). Although the extraction rate is easy to measure, it can be misleading because the oil content of palm fruits can vary considerably, even within the same variety. Typically, the traditional process would have an efficiency of 20-40% for hard oil and 30-50% for soft oil (Nwanze 1965; Moll 1987). A 50% efficiency is equivalent to an extraction rate of about 5.5% with Dura or 11% with Tenera.

## Small Expellers

Small expellers are down-scaled versions of the equipment used by large-scale firms. These presses rely on a shaft with a spiral flight ("worm") that turns horizontally or vertically in a cage. As the material fed into the press is pushed forward by the worm, the pressure forces oil out through the perforated sides of the cage and the remaining fiber and kernels are released at the end of the cage. The ability to depulp and expel oil simultaneously is a major advantage of this type of press. The disadvantages are capital cost and wear on the shaft and cylinder. Examples of such presses include the Colin and the Caltech.

### The Colin Press

The Colin press is a low pressure, continuous feed expeller

patented in 1904. The motorized version uses a 5-7 hp engine (Egli 1987). The manual Colin has a capacity of 100 kg of stripped fruits per hour and the motorized version can process 250 kg/hour or more. Because of bottlenecks in other stages of processing, these presses would generally be operated a maximum 4 hours per day (OPC n.d. (a)). The motorized Colin is too large for an individual smallholder, unless service pressing is also being offered. The Colin is best-suited for Tenera because the efficiency drops when the large Dura kernels come in contact without pulp between them. The extraction rate of the Colin press from ffb averages 10% with Dura and 17% with Tenera (Spaenhoven 1986; OPC n.d. (b)).

The Colin is sturdy and reliable. The original version had cast iron components, but these are too expensive to use now in Cameroon. The local version has an expected lifetime of 20 years. OPC currently sells a manual Colin at CFA 2,968,736, excluding the 10.99% sales tax. The base price for the mechanized version is CFA 4,107,580 with a gasoline motor or CFA 4,049,915 with an electric motor. There is little potential for further price decreases for the domestically produced Colin because it is complicated to recondition or manufacture (Laffitte 1987). The gasoline-powered Colin consumes 2.7 liters (l) of fuel per hour at a cost of CFA 250/l and 3 l of lubricating oil per month at CFA 800/liter.

**The Horizontal Caltech Expeller**

The horizontal Caltech expeller is a modification of the Colin designed by Daniel Turquin and Jean Claude Barnaud, both of

the Altech Co. in France, and Carl Bielenberg, then with ATI. Financial support for its development was provided by ATI, GRET, la Fondation de France and la Boutique d'Innovation Technique.

The Caltech is simpler and smaller in scale than the Colin. It differs from the Colin in substitution of a gear reducer for gearing used to slow the speed between the rotation of the crank (or pulleys in the motorized model) and the screw (Bielenberg 1986). The gear reducer, the only major part that has to be imported, constitutes about half the total materials costs of the manual model (Laffitte 1987). However, it simplifies construction and is less susceptible to breakdowns because gears and precision transmission components are no longer needed.

The manual, horizontal Caltech is easier to use than the manual Colin because it has a reduction ratio of 1/15, rather than 1/12. It is being operated by women's groups without difficulty. The motorized Caltech requires two-thirds of the gasoline and lubricating oil consumed by the motorized Colin. However, operating costs per unit of output are similar for both presses because the motorized Caltech has a lower production rate. The Caltech's expected lifetime is also less than that of the Colin, approximately 10 years (Bielenberg 1987).

The manual horizontal Caltech has a capacity of 90 kg of stripped fruits per hour, while the motorized version can handle 170 kg/hour. It takes 4 unskilled workers to operate the manual pressing system, and only 3 for for the motorized system (OPC 1987a). The extraction rate is 9% from Dura ffb if the fibers are pressed twice. Otherwise, the efficiency may be lower since the

large kernels of Dura will be in contact with each other during pressing. This is not generally done in Cameroon. The more common alternative there is to use a mix of 30-40% Dura and 60-70% Tenera. The extraction rate from Tenera alone is 16% for the manual press and 17% for the motorized version.

In mid-1987, cash prices for the horizontal Caltechs were CFA 988,711 for the manual model and CFA 1,753,422 for the 2-hp gasoline-powered model. These prices include delivery and installation, but not taxes (OPC 1987a). Production costs at this recently established manufacturing enterprise could be decreased by reducing overhead, expanding volume through exports, diversifying production, or relying more on subcontracting of parts.

**Vertical Caltech Expeller**

The vertical Caltech expeller was designed in 1985 by an ATI engineer to meet the needs of smaller-scale, artisanal producers of palm oil who could not afford a manual, horizontal Caltech. It can depulp and press simultaneously. The vertical model is much cheaper because the design is simpler and nearly all of the parts are domestically made. The change in orientation of the cage and auger does not affect the extraction efficiency (Bielenberg 1988). With financial support from ATI, OPC built a prototype vertical Caltech, which was field tested in mid-1987. By the end of 1987, 6 additional presses of this type had been sold.

The vertical Caltech does not require an expensive, imported gear reducer; complicated gearing susceptible to breakdowns; or a

cast flywheel because it develops the low-speed, high-torque motion of the expeller screw by using a capstan, rather than gearing down the relatively high rotational speed of a hand crank. Excluding tax, the cash price is only CFA 386,545 installed. Because of its lower cost, it has a potential for wider dissemination. However, it can only be operated manually. The expeller screw is driven by pushing on the two sides of a wooden pole that turns the attached capstan. The pole can either be pushed by two workers walking in a circle or by one draft animal. Alternatively, the vertical Caltech could be run by stationary operators passing six poles among themselves (Bielenberg 1986).

Social acceptance of a press operated in this way must be carefully assessed in the local context. In some parts of Africa, people might shun walking in a circle to turn a capstan because they associate that type of work with beasts of burden. These are generally the areas where draft animals could operate the press because a tradition exists for their use. In southern Cameroon, cattle are not generally available due to the tsetse fly and only a few donkeys have been introduced. As a result, there appears to be no social stigma to this form of human labor.

In theory, the vertical Caltech has the same capacity as the manual, horizontal Caltech. However, in view of the different mode of labor use, a conservative estimate of its capacity would be 70 kg of stripped fruit per hour (OPC 1987a). This capacity would be suitable for artisanal production by one extended

family. It is unlikely that there would be a large demand for service milling with the vertical Caltech in areas where a horizontal Caltech or Colin are reasonably close. Although it is too soon to tell, the vertical Caltech is expected to last for 10 years.

## Screw Operated Batch Presses

Screw-operated batch presses have been used for palm oil extraction in Africa since around 1930 (Nwanze 1965). They consist of an upright cage containing a movable piston, which is acted upon by a centrally located screw. The screw, usually turned by a pair of long handles, rotates inside a nut fixed in the head of a heavy frame surrounding the cage.

Screw presses operate on a batch basis and do not depulp the fruit, a step that must be performed separately prior to pressing. Depulping is usually done in a mortar with a pestle. Potential buyers in the Otele region are not interested in equipment that does not depulp and press simultaneously because they have grown accustomed to use of the Colin expeller (Laffitte 1987). In less prosperous palm-growing areas in Cameroon and other countries in West and Central Africa, there may be a demand for small, inexpensive screw-operated batch presses for palm oil production.

The extraction efficiency is relatively low for the less sophisticated presses of this type. Nevertheless, these presses are simple and inexpensive compared with other mechanical methods, and labor-saving and efficient in comparison to the traditional technology. Examples of screw-operated batch presses

include the TCC, SODIZI, KIT, and UNATA presses.

**TCC (Kumasi) Press**

The Technology Consultancy Centre (TCC) at Kumasi, Ghana developed a manual, spindle press. This press consists of a centrally mounted screw or spindle, a perforated cage, and a nut. When the nut is turned, it forces a piston or pressing plate down into the cage. Two operators turn the handles of the press by walking in a circle. They can generate a pressure of 40 $kg/cm^2$, excluding friction losses. The TCC press is unusual in that it eliminates the need for a heavy frame by fixing the nut to a base plate under the cage. Four workers in Ghana processed an average of 45 kg of stripped Tenera per hour with this press and the extraction rate was 14.5% (Dichter 1987).

TCC has also developed a separate, mechanical pounder. This horizontal pounding machine has a capacity of 100 kg of cooked fruit per hour. A complete TCC pressing system would consist of 1 pounder, 2 presses, and a steam cooking kettle. With this system, 8 women could process as much as 600 kg of palm fruit in an 8-hour day (Merx 1987). Technoserve is promoting the TCC press in Ghana. It has also been used in Sierra Leone (APICA/GATE 1983).

**SODIZI (Casamance) Press**

Environnement et Developpement du Tiers Monde (ENDA), an NGO, developed a smaller, version of the TCC press in the early 1980s and the design was further modified in 1987. This model is known as the SODIZI press after the original manufacturer in

Senegal. It is now being fabricated by informal sector blacksmiths using locally available materials except for the cast screw and perforation of the sheet metal, which are still done by SODIZI. Other purchased materials include bolts and iron plates. The cage and recovery drum can be made from a recycled gasoline drum, the piston is sheet metal, the armatures are from truck springs, and recycled nuts are also used (ENDA 1987).

The pressure and hence extraction efficiency attainable with the SODIZI is much lower than with the TCC or other manufactured presses of this type. In practice, users are able to raise the extraction efficiency by multiple pressings, with hot water added to the fiber before repressing. The expected lifetime is also shorter, about 3 years. In Senegal, the SODIZI press sells for around CFA 55,000 (Perry 1987).

Most of the dissemination effort for the SODIZI press has been at Casamance in southern Senegal with ENDA financing to village groups. As of 1985, 70 were sold around Casamance and 13 more were in production (ENDA 1985). ENDA has also promoted the press in Guinea-Bissau.

### KIT Vertical Screw-Operated Batch Press

The Royal Tropical Institute of the Netherlands, KIT, emphasizes the importance of the entire pressing system with a screw-operated batch press, which includes

1. Steaming of the fruit,
2. Pounding to loosen the pulp from the fruit (requiring less effort than in the traditional process which has to macerate the pulp as much as possible),
3. Reheating of the pulp,
4. Pressing,

5. Recycling the fibers (with Tenera) either in fres fibers or separately, and
6. Clarification.

The KIT process is not tied to a particular press and may be used with KIT's own screw-operated press, the UNATA, or the TCC press.

The KIT screw-operated batch press can press 35-60 kg of cooked, pounded palm fruit per hour in its 8-l cage. Two perforated cages are provided to reduce delays in loading and unloading. The short lever designed for manual operation only can also be fitted with an extension arm (Altes, Heubers, and Merx n.d.; 1986a). If the KIT system is used, the extraction rate could be 75% or more under typical field conditions (Spaenhoven 1988). This press has the advantage of being portable since it only weighs 20 kg (Altes 1982). In 1982, it costs $350 (KIT 1982).

The KIT press may be appropriate for processing low quality, wild palm fruit in Senegal, the Gambia, and Guinea Bissau via a semi-traditional process. In these countries, the wild fruit is small and the oil content of the pulp is low. The semi-traditional process involves steaming the fruit and moderate pounding to separate the pulp and kernel. The pulp is reheated in a KIT steaming kettle and pressed. Part of the oil enters the water and is separated in the same manner as in the traditional process. The extraction efficiency is about 60%, compared to 40% for the traditional process, which also takes more work. In Casamance, Senegal, this press is rented to processing groups in different places. In Guinea-Bissau, the material remaining after cooking the separation water, "bagash", is eaten (Altes 1988).

**UNATA Press**

The UNATA 4201 press was developed in cooperation with KIT. It has a reinforced frame and a 17-l cage designed to reduce deformation during extraction of the last bit of oil. Five press plates are used to equalize the pressure and allow recovery of the cake in small blocks. Points of wear in the design have also been improved (Altes, Heubers, and Merx 1986b).

A pressure of 40 $kg/cm^2$ is needed for good oil recovery, and women can exert this without difficulty (Altes, Heubers, and Merx 1986b). A field test in Togo showed an efficiency of at least 75% with the UNATA when the pounded material is reheated for 2-3 hours before pressing, compared to 88% for the motorized horizontal Caltech (Spaenhoven 1988). A conservative estimate of the extraction rate from ffb is 8.5% with Dura, and 15.5% with Tenera. Realistically, a batch of 500 kg of stripped fruits can be processed with this press in a 6-hour day. It would take 2 women 6 hours to steam this much fruit. On the following day, 24 person-hours of labor would be needed for threshing and pounding and 3 hours for reheating Tenera (Merx 1987). Pressing can be done as quickly as with the other manual, horizontal Caltech, but additional time is spent in depulping and reheating. Half of the oil is obtained during reheating and half in pressing (Spaenhoven 1988). A cement mortar is recommended for the pounding. A special steaming kettle with an oil reservoir for reheating the pulp is an integral part of the KIT system.

Princen and Spaenhoven (1987) emphasize the importance of the auxiliary equipment for pounding and cooking of fruit, and

oil clarification. The estimated cost of the press and auxiliary equipment manufactured in Cameroon would be CFA 370,000 (Spaenhoven 1988). The expected lifetime of the press is 10 years (Bielenberg 1987), and it was designed to function with minimal need for space parts (Spaenhoven 1988).

Although the UNATA may be appropriate for farmers with small plots of natural or improved palm due to its low capital costs, it requires more labor than the vertical Caltech and yields a little less oil. However, the UNATA can also be used with other oilseeds, which require a pressure of 40 $kg/cm^2$, twice as much as for palm fruits. The 4202 model is adapted for oilseeds. Approximately 50 UNATA presses have been sold in Africa, Madagascar, Colombia, and Vietnam. About half of these are being used for palm oil extraction and the rest for other oilseeds (Princen and Spaenhoven 1987). APICA has tested the UNATA press in Cameroon.

## Hydraulic Presses

Another technology for palm oil extraction is the hydraulic press. Operation of a hand pump causes fluid pressure to build up, forcing a piston down into the perforated cage containing the digested fruit. The piston is connected to a plunger that squeezes the material into packets, which may be separated by pressing plates. As a pressure relief valve opens, the piston returns up to its original position.

A hydraulic press is easy to operate and can produce a higher pressure than a screw-operated batch press. A serious disadvantage is the need for precision machining of cylinders,

pistons, and valves as well as their susceptibility to corrosion in humid, tropical climates (African Regional Centre for Technology 1986). Manual examples include the NIFOR and KIT hydraulic presses. Motorized hydraulic presses have been produced by European firms such as Stork and de Wecker as well as an Indian company, AGRICO.

**NIFOR Manual Hydraulic Press**

Because of the high cost of imported, hydraulic presses, the predecessor of NIFOR, the Nigerian Institute for Oil Research, modified a Stork design in the 1950s with FAO/UNDP support. The NIFOR press was promoted by KIT and International Technological Assistance (ITA) of the Netherlands in the 1960s. It is less expensive than the imported Stork because it can be made locally using easily assembled components. The extraction rate reportedly exceeds 17-18% (Moll 1987).

NIFOR recommends some optional auxiliary equipment with the NIFOR press: (1) an open-fired sterilizer/cooker with a capacity of 1 t of ffb, (2) a motorized, rapid digester (macerator) allowing a throughput of 250 kg of cooked fruit per hour, (3) a clarifier with a capacity of 800 l, (4) a rotary stripper, and (5) a multipurpose digester/cooker/sterilizer for 150 l of stripped fruit (ECA 1983).

**KIT Hydraulic Press**

KIT's manual hydraulic press was available in two sizes: one with a capacity of 75-120 kg of ffb per hour and the other for processing 150-180 kg of ffb per hour. In 1982, the smaller

press cost $1,200 and the larger one $1,500 (KIT 1982). Despite its relatively high cost, this press is fragile (Spaenhoven 1986). The hydraulic jack has an effective force of 20-30 t, exerting a maximum pressure of 40 kg/cm$^2$ (Altes, Heubers, and Merx n.d.). A separate step of depulping the palm fruit is necessary (APICA/GATE 1983).

**European, Motorized Hydraulic Presses**

Stork produces small, motorized hydraulic presses and auxiliary equipment for minimills. The Stork Standard Jr. mill can process 600-750 kg of ffb per hour, but is complicated to operate (Van Beuningen, Thijsen, and Rijnsburger 1984).

De Wecker, a firm in Luxembourg, exports a motorized hydraulic press that uses a screw to combine maceration and pressing of palm fruits (APICA/GATE 1983). The de Wecker PM-50 has a capacity of 600 kg of ffb per hour and can either be operated by hand or with a motor (GRET 1984b). Both the Stork and de Wecker presses cost $8,000-10,000, excluding auxiliary equipment (African Regional Centre for Technology 1986).

**An Indian, Motorized Hydraulic Press**

AGRICO in India makes a press similar to the TCC design, except that a hydraulic system replaces the spindle operation. The press capacity is 1,000 kg per hour and it exerts 60 t of pressure. The AGRICO press can achieve an extraction rate of 17-18% with Tenera, and does not require constant labor. Unfortunately, it requires a lot of maintenance and has reliability problems. Hadley and Hadley (1986) found that three-

quarters of the mills using AGRICO presses in Ghana were not operating due to equipment failures.

The following auxiliary equipment is recommended with this press: (1) a mechanical bunch stripper, (2) digester or pounding machine for stripped fruit, (3) clarifier with mechanical pump, (4) dryer for the fiber and kernels, and (5) a separator to remove the kernels. Total costs of this equipment and a building were estimated at $65,000 in Liberia in 1984. With this system, a mill could process 5,000 kg of ffb in 8-10 hours. It is claimed that the processing cost would be about one-third of the imputed labor cost of the traditional process (Wadhwa and Minotra 1984).

### Phase Separation Extractors

Phase separation extractors rely on the difference in density between oil and water and use a decanting process rather than pressing or expelling. Examples include the relatively sophisticated Tropic 10 extractor and the simple, cottage-scale Wax Press.

The Tropic 10 extractor, developed specifically for palm oil, won a silver medal at the Brussels World Exposition on Inventions in 1984. It has a capacity of 500 kg of stripped fruit per day and can be operated by two women. The extractor vat has a capacity of 100-150 l of cooked, pounded palm fruit and is mechanically inclinable by 15$^{o}$ in both directions to assure emptying of the fruits. Attached rods allow the horizontal axis composed of 3 rows of 6 blades to move in a complete circle. At the same time, the assembly can rotate 60 turns per minute due to

two levels of supports and ball bearings. The movement can be motorized for an electric or gasoline engine if a gear reducer and transmission chain are added. The vat and mixing assembly must be made of stainless steel (Ateliers Julein Heine 1985).

The Wax Press consists of a metal drum with a double bottom containing a hole to receive the axis. The wooden axis has 3 steel cross bars. A trap permits removal of fibers and pulp. The assembly rests on a wooden bridge with 2 steel crossbars (Langley 1982).

### Auxiliary Equipment for Artisanal Production of Palm Oil

Table 1 summarizes the characteristics of various artisanal-scale presses for palm oil production. Since pressing speed is not usually the limiting factor in artisanal-scale production (Nwanze 1965), auxiliary equipment may be needed for the other steps such as cooking, bunch stripping, or pounding of fruits, and clarification of raw oil.

### Cooking of Palm Fruits

Women do the cooking for artisanal palm oil production in Cameroon. With a press such as the Colin or Caltech that simultaneously depulps the stripped fruit and expels oil, only one cooking is necessary. It is either done before bunch stripping if a mechanical bunch stripper is used or afterwards if the fruits are stripped by hand. Two cookings are needed when the equipment does not simultaneously depulp the fruit and expel oil -- the first before pounding or maceration and the second before pressing.

TABLE 1

Summary of Characteristics of Selected Artisanal-Scale Presses[a]

| Criteria | TYPE OF PRESSES: MANUAL, HORIZONTAL EXPELLERS | | | MOTORIZED, HORIZONTAL EXPELLERS | | | SCREW-OPERATED BATCH PRESSES | | | | HYDRAULIC PRESSES | | | | PHASE SEPARATION EXTRACTORS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Manual Colin | Manual Horizontal Caltech | Vertical Caltech | Motorized Colin | Motorized Horizontal Caltech | European Models | TCC (Kumasi) | SODIZI (Casamance) | KIT | UNATA 420I | NIFOR (Stork) | KIT | European Motorized Models | Motorized AGRIGO | Tropic 10 | Max Press |
| Fabricated in an LDC | Y | Y | Y | Y | Y | N | Y | Y | N | N | Y | N | N | Y | N | Y |
| Currently marketed | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | N | N | · | Y | Y | N |
| Capital costs | M/H | M | L | H | H | H | L | L | L | L | M | M | H | M | L | L |
| Availability of spare parts locally | Y | Y | Y | Y | Y | N | Y | Y | N | N | Y | N | N | N | N | Y |
| Ease of repair | H | H | H | H | H | L | H | H | M | M | L | L | L | L | M | H |
| Expected lifetime | H | M | M | H | M | H | L | L | L | L | M | M | H | L | M | L |
| Continuous operation | Y | Y | Y | Y | Y | Y | N | N | N | N | N | N | N | N | N | N |
| Simultaneous pressing and depulping | Y | Y | Y | Y | Y | Y | N | N | N | N | N | N | N | N | N | N |
| Ease of use in pressing | M | M | M | H | H | H | M | M | M | N | H | H | H | H | H | H |
| Adapted for production of other oils | N | N | N | N | N | Y | Y | N | Y | Y | N | N | Y | N | N | N |
| Production rate | M | M | M | H | H | H | L | L | L | M | M | M | M | H | M | L |
| Extraction efficiency with Tenera | H | H | H | H | H | H | M[b] | L | M[b] | M[b] | M[b] | M[b] | H | H | L/M | L |

Key: H = High
M = Medium
L = Low
Y = Yes
N = No

[a] Some criteria adapted from GRET 1984.

[b] If the pounded pulp is carefully prepared and reheated sufficiently, a high efficiency can be achieved.

Traditionally, recycled metal drums are used in the cooking and the fuel is palm kernels and fiber from the pressed fruit. Recycled drums cost CFA 4,000 each in Cameroon and a press owner would need five. OPC offers a package of 5 new, metal drums with stands and handles for CFA 39,000, excluding sales tax (Toukam 1987). The UNATA/KIT system includes 4 sterilization drums and 2 reheating vats that have a capacity of 110 kg of pounded fruit each.

**A Manual Bunch Stripper**

In Cameroon, OPC is producing a simple, manual device for removing palm fruit from the bunches. The bunch stripper is a hexagonally shaped drum composed of wooden slats. By turning a crank in alternate directions, 40-50 kg of cooked ffb are shaken loose by gravity and friction in 3-4 minutes. Any fruits left attached are removed by hand as the bunch stalks are unloaded from the drum. This step takes another 2 minutes (OPC 1985).

The bunch stripper allows processing of fruits the day after they are harvested. By contrast, stripping of fruits by hand would be done over a 3-4 day period, which could damage the quality of the fruits. The OPC bunch stripper costs CFA 171,165, excluding sales tax (Toukam 1987).

The demand for the bunch stripper has been lower than expected. Although 540 kg of ffb can be stripped in an hour with this machine, compared to only 69 kg/hour by hand, the price appears to be too high relative to the benefits. At the prevailing wage of CFA 800 for 8 hours of casual, agricultural labor, over 1 year the time saved in bunch stripping at a 3-ha

plantation would be worth CFA 11,400 for a Dura farmer and CFA 34,300 for a Tenera farmer.

Just considering capital costs, the payback period for a manual bunch stripper would be 15 years with Dura and 5 years with Tenera. Accounting for operation and maintenance costs and the time value of money would increase the cost. Nevertheless, a bunch stripper could be beneficial for a bigger operation. The bunch stripper has another disadvantage if the palm stands are distant from the press location and the device is kept near the press for reasons of security. In that case, the whole bunches have to be transported rather than just the stripped fruits and this may cancel out some of the labor time savings.

**Clarification of Raw Oil**

After extraction via either the traditional process or a press, raw palm oil contains a lot of water, fiber, and sediment. Nearly all artisanal producers in Cameroon clarify the oil by boiling it with water in a recycled metal drum. As the water evaporates or sinks below the oil, which is lighter, the clarified oil is skimmed off and the sediment at the bottom of the drum removed.

A rectangular clarifier is available for the UNATA press for easier filling and emptying and greater stability. This clarifier has a lower vessel filled with water to transfer heat from the fire below to the upper vessel. A tap in the upper vessel is used to remove the water separated from the raw oil. Then, the clarified oil is recovered. OPC is manufacturing a simpler clarifier in Cameroon, an adaptation of a NIFOR design.

This modified metal drum has a metal funnel for entry of raw oil, an inner reservoir and tap for the clarified oil, an overflow tube, and a release tap for the sediment.

There has been little demand for the new clarifiers in Cameroon because they are only a small improvement over readily available metal drums and potential users find the price difference too large. The OPC clarifier costs CFA 115,000, excluding tax, while a new metal drum is only CFA 8,000. A press owner would need 1 clarifier.

### Economic Analysis of Selected Pressing Technologies

The economic analysis is based on mid-1987 prices. Net present values are calculated at a 15% real discount rate over a 10-year time horizon. An opportunity cost of CFA 4.20 per kg is imputed for Dura ffb based on the value of harvesting time; a market price of CFA 20/kg is available for Tenera bunches. Household labor is valued at the casual agricultural wage rate of CFA 800/day and part-time management costs are imputed at CFA 150,000 per year. Fuelwood and water collection time are included in the labor cost and waste palm kernels are also used as fuel. Land requirements for processing are minimal and it is assumed that the property is already owned. Buildings and storage costs are assumed to be CFA 200,000 for all presses except for the traditional process, Artisanal palm oil producers do not need licenses in Cameroon and pay no income taxes.

In the base case, A, artisanal producers receive the current price of CFA 334 per kg of palm oil in rural Cameroon, while case B reflects a 33% price decline and case C a 33% price increase.

Six scenarios of varying capacity use are considered. Table 2 lists other assumptions behind the economic analysis of selected artisanal-technologies for palm oil extraction.

The results are shown in Table 3. A relatively large capital investment is needed for the motorized Colin; manual Colin; motorized, horizontal Caltech; and to a lesser extent, the manual, horizontal Caltech. The vertical Caltech, UNATA and SODIZI units are the least expensive and the traditional process requires almost no capital investment.

Although the traditional process is the most labor-intensive alternative, it is also the least productive and least profitable. The motorized presses provide about one-third as much employment as the manual ones. Differences in labor intensity among the manual presses are less dramatic, but those presses that require a separate pounding step (UNATA and SODIZI) use 18-27% more labor than the cheapest alternative that accomplishes both steps (vertical Caltech).

At the current price of artisanal palm oil in Cameroon, the traditional process has a negative net present value for processing Dura or less than 10 ha of Tenera. Although households carrying out the traditional process are not losing money, they are earning an imputed wage of less than CFA 800 per day for their work. That explains why the traditional process is used so little in a high-wage area like Otele while it persists in areas where little wage employment is available.

At current prices, 10 ha or more of Tenera are required for profitable use of the manual and motorized Colin expellers. The

TABLE 2
Assumptions For the Economic Analysis of Artisanal- and Small-Scale Technologies

- Cases Analyzed

  I. 3 ha Dura processed by farmer or group
  II. 3 ha Tenera processed by farmer or group
  III. 10 ha Dura processed by farmer or group
  IV. 10 ha Tenera processed by farmer or group
  V. 20 ha Dura, half processed by farmer or group and half as service milling
  VI. 20 ha Tenera, half processed by farmer or group and half as service milling.

- Press operation 4 hours/day, except for traditional process.

- Service milling fee -- 20% of oil pressed, plus fuel cost if motorized press. Labor and fruits for service milling provided by client. Transport of product refers to own product plus share of service milling product.

- Repair costs
  Motor -- CFA 200,000 for the motorized Colin in yrs. 3 and 8, and CFA 115,000 for the motorized Caltech in yrs. 2, 6, and 9

- Miscellaneous -- CFA 80,000 for the manual and motorized version of the Colin and Caltech presses, zero for the traditional process, and CFA 40,000 for the others.

- Replacement of auxiliary equipment:

| | |
|---|---|
| Cooking drums and clarifier -- yrs. 3, 5, 7, 9 | 8,000 |
| Bunch stripper (motorized Caltech and Colin) -- yr. 6 | 171,165 |
| UNATA: cement mortar (labor and materials) -- yr. 6 | 20,000 |
| UNATA: 3 wooden pestles -- yrs. 4, 7 | 5,000 |
| SODIZI: 2 wooden mortars and pestles -- yrs. 4, 7 | 10,000 |

- Replacement of motor:

| | |
|---|---|
| Colin -- yr. 6 | 400,000 |
| Caltech -- yrs. 4, 8 | 230,000 |

- Replacement of screw in yrs. 3, 5, 7, 9 -- CFA 122,000 for Colin presses, CFA 61,000 for horizontal Caltech presses, and CFA 65,000 for vertical Caltech. Replacement of nut and spindle for UNATA in yr. 6 -- CFA 65,000. Replacement of other parts for UNATA in yr. 6 -- CFA 98,500. Annual refitting costs for SODIZI press CFA 23,000.

- Replacement of wooden thrust bearings for vertical Caltech each year -- CFA 3,000.

- Salvage value at beginning of year 11.
  Manual Colin -- CFA 984,400 (50% of capital cost less CFA 500,000 for overhaul)
  Motorized Colin -- CFA 1,553,800 (50% of capital cost less CFA 500,000 for overhaul)
  SODIZI -- CFA 13,700 (67% of capital cost less CFA 23,000 for repairs).

TABLE 2 (cont'd)

| Press Operations | Traditional | Manual Colin | Motorized Colin | Manual, Horizontal Caltech | Motorized Horizontal Caltech | Vertical Caltech | UNATA | SODIZI |
|---|---|---|---|---|---|---|---|---|
| Capacity use rate (%) based on press operation 4 hours/d, 260 d/y = 1040 h/y) | | | | | | | | |
| Case I | - | 5 | 2 | 5 | 3 | 7 | 5 | 11 |
| II | - | 14 | 6 | 16 | 8 | 20 | 17 | 32 |
| III | - | 16 | 6 | 18 | 9 | 23 | 20 | 35 |
| IV | - | 48 | 19 | 53 | 28 | 68 | 57 | - |
| V | - | 32 | 13 | 35 | 19 | 45 | 38 | 70 |
| VI | - | 95 | 38 | - | 56 | - | - | - |
| Extraction rate from ffb (%)[a] | | | | | | | | |
| Dura | 6.0 | 10.0 | 10.0 | 9.0 | 9.0 | 9.0 | 8.5 | 7.5 |
| Tenera | 11.5 | 17.0 | 18.0 | 16.0 | 17.0 | 16.0 | 15.5[b] | 14.0[b] |
| Unskilled Labor Time Required in Processing 3,000 kg of Palm Fruit[c] (person-hours) | | | | | | | | |
| Bunch stripping | 44 | 44 | 5.5 | 44 | 5.5 | 44 | 44 | 44 |
| Fuelwood collection | 15 | 15 | 15 | 15 | 15 | 15 | 20 | 20 |
| Preparation, cooking, pounding, reheating of fruit, and pressing | 226 | 66 | 20 | 73 | 29 | 94 | 120 | 136 |
| Clarification | 45[d] | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Packaging | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Total person-hours | 340 | 150 | 65.5 | 170 | 74.5 | 178 | 209 | 225 |
| person-days | 42.5 | 19.0 | 8.5 | 21.5 | 9.5 | 22.5 | 26.5 | 28.5 |

[a] Assuming 550 kg of stripped fruit per tonne of the ffb, and an oil content of 11% of the ffb weight.
[b] With reheating of pressed material and repressing of fibers for recovery of additional oil.
[c] 1.0 ha of Dura or 0.33 ha of Tenura.
[d] Longer time due to greater presence of contaminants.

Sources: APICA 1982; ECA 1983; OPC various; Hadley and Hadley 1986; Dichter 1987; ENDA 1987; Wiemer and Altes 1987; Altes 1988; Spaenhoven 1988.

TABLE 3

Summary of the Economic Analysis of Artisanal- and Small-Scale Presses (1000 CFA)

| | Traditional | Manual Colin | Motorized Colin | Manual, Horizontal Caltech | Motorized, Horizontal Caltech | Vertical Caltech | UNATA | SODIZI |
|---|---|---|---|---|---|---|---|---|
| Capital Costs | 10 | 3,197 | 4,507 | 1,217 | 2,153 | 614 | 370 | 293 |
| Capacity (stripped fruits, kg/hr) | - | 100 | 250 | 90 | 170 | 70 | 83 | 45 |
| Annual Wages Paid to Unskilled Labor | | | | | | | | |
| I | 102 | 46 | 20 | 52 | 23 | 54 | 62 | 68 |
| II | 306 | 137 | 61 | 155 | 68 | 162 | 187 | 205 |
| III | 340 | 152 | 68 | 172 | 76 | 180 | 208 | 228 |
| IV | 1,020 | 456 | 204 | 516 | 228 | 540 | 624 | - |
| V | - | 152 | 68 | 172 | 76 | 180 | 208 | 228 |
| VI | - | 456 | 204 | - | 228 | - | - | - |
| Net Present Value | | | | | | | | |
| I-A | (2,448) | (2,998) | (4,369) | (1,510) | (2,653) | (829) | (928) | (784) |
| II-A | (934) | (7,743) | (14,023) | 1,126 | (107) | 5,051 | 3,718 | 2,440 |
| III-A | (1,308) | (1,041) | (2,300) | 98 | (878) | 749 | 423 | 226 |
| IV-A | 3,738 | 6,762 | 7,043 | 6,932 | 7,609 | 7,519 | 6,548 | - |
| V-A | - | (239) | (1,498) | 820 | (156) | 1,471 | 1,104 | 827 |
| VI-A | - | 21,275 | 21,591 | - | 21,883 | - | - | - |

Colin expellers are not profitable with 20 ha of Dura (half as owner production and half as service milling). The manual, horizontal Caltech, vertical Caltech, and UNATA require a minimum of 10 ha of Dura or 3 ha of Tenera for profitability. A motorized, horizontal Caltech can only be justified with at least 10 ha of Tenera. The SODIZI is most suitable with 3 ha of Tenera and is unprofitable with Dura unless 10 ha of fruit are processed.

The relative profitability of these presses varies with the scale of operation. None of these presses is worth buying if the owner only has access to 3 ha of Dura. With either 3 ha of Tenera or 10 ha of Dura, the vertical Caltech is most profitable, followed by the UNATA. The best choices given 10 ha of Tenera are the motorized, horizontal Caltech and the vertical Caltech. With 20 ha of Dura (half as service milling), the vertical Caltech is best and the UNATA next best. The motorized, horizontal Caltech is preferable for 20 ha of Tenera (half as service milling), although the manual and motorized Colin presses would be almost as profitable.

These findings are quite sensitive to the price of palm oil. If the price falls by one-third, an investment in any of these presses is unwarranted with the quantities of Dura analyzed, and 10 ha of Tenera becomes unprofitable for all but the vertical Caltech and the motorized, horizontal Caltech.

Conversely, if the price increased one-third, there is a turnaround in profitability in many of the scenarios. For example, all of the upgraded presses except the motorized Colin

become economically profitable with 10 ha of Dura. With 3 ha of Tenera, the traditional process; manual and motorized Colins, and motorized, horizontal Caltech turn profitable.

## Conclusions

If a sufficient quantity of palm fruit is processed, improved artisanal-scale presses are economically viable. However, buyers may have noneconomic reasons for purchasing a press. Some have bought motorized presses even though they were advised that a manual press would be more profitable, given their scale of oil palm production. Where artisanal producers have experience using a manual expeller, a motorized unit confers social status and manual presses that require a separate, laborious pounding step to depulp the fruit before pressing are unlikely to have a sizable market.

In many cases, buyers of an expeller have off-farm jobs locally or in Yaounde so that palm oil production is either a sideline or means of ensuring some income after retirement or upon returning to the village. Also, a gift of a productive asset like an oil press can provide income and an occupation for relatives remaining in the village, without creating dependency through cash handouts. It also is tangible evidence of the donor's generosity that can be noticed by neighbors, friends, and other relatives.

Although the profitability of owning an expeller could be substantially increased by offering service pressing to neighbors, many of the recent buyers want to avoid the bother of supervising users or having to repair parts more frequently.

Some customers might not always use someone else's equipment with care or might try to avoid full payment for the amount pressed. Many owners report that pressing services are currently in sufficient supply within their vicinity from old, but still functioning Colin expellers. In the future, many of these Colin expellers may no longer be workable. Also, if inflationary expectations are high, it can be economically rational to buy any durable goods for future use or resale instead of holding cash.

In two cases so far, buyers have broken parts of a press through misuse. Although the manufacturer does demonstrate use of the press at the time of installation and leaves a manual for future reference, there may be a need for more extensive training. It is also important to ensure that the actual users participate in the training, rather than the buyer. Fortunately, the proximity of the Plan Palmeraies Villageoises program headquarters has facilitated good communications between expeller owners near Otele and the manufacturer when repairs are needed. The importance of a local institutional connection in ensuring acceptance of an innovation by rural producers and maintaining effective use of the equipment is one of the lessons learned from this project. Also, to reduce downtime, common spare parts should be left with the buyer at the time of purchase, especially where purchasers are scattered or in relatively inaccessible areas.

Younoussi (1985) estimates that the demand for horizontal Caltechs is about 24 per year in Cameroon. In fact, this is well above the dissemination rate of 11-12 per year for the original

Colin expellers when they were being sold at a time when the ratio of the cost of a press to the price of palm oil was more favorable than it is now (GRET 1986). The initial cost of a horizontal Caltech is still relatively high for most artisanal-scale producers of palm oil and only a limited amount of financing is now available. Because of its much lower capital costs, the market for the vertical Caltech may be larger.

Places such as Bafang and Bamenda that have a large area of Dura and few existing Colin expellers are potential markets; but most palm oil producers there might have difficulty affording any mechanical equipment. In the less poor areas around the industrial estates, there are reports that the large companies might not renew contracts with smallholders who are relatively far from a mill because of high transport costs. This shift could stimulate the demand for small-scale expellers.

The number of expellers sold per year could increase if the capital costs could be reduced through further design simplications, improvements in manufacturing productivity through expansion of volume to reap economies of scale, and cutting overhead costs.

Press sales in Cameroon could be accelerated if a linkage could be made with a government agency or regional development authority. A drawback of working with the governments is the slowness of payments in effect obliges firms to finance the program. By expanding to serve neighboring countries, OPC could potentially produce as many as 50-60 palm oil expellers per year (Laffitte 1987). OPC has received an order for 5 horizontal

Caltechs for the World Bank-financed ITURI project in Zaire. The Altech Co. fabricated one motorized, horizontal Caltech in France for an organization in Guinea. In 1988, APICA will complete a market study for Caltech presses in Benin, Togo, Ivory Coast, and Guinea - Conakry. Due to trade restrictions and tariffs, potential buyers outside Cameroon might be better off if the equipment could be economically manufactured domestically. In that case, OPC could license use of the design and provide technical assistance to other manufacturers.

Palm oil processing is an important economic activity in West and Central Africa, generating income and employment for rural producers, and providing a product that matches the tastes of domestic, urban and rural consumers. Artisanal producers add value locally to an agricultural product with a lower capital investment per unit of output than is possible on a large-scale. Where the traditional process is still prevalent, an upgraded technology could significantly increase productivity and incomes in artisanal palm oil production. In many areas, however, the likely buyers already have access to mechanical pressing services so their purchases would not result in a large increase in palm oil production.

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