

## Application of Enzymes to Aqueous Palm Kernel Oil Extraction

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**Abstract** An enzyme-assisted fat extraction technique has been applied to the aqueous extraction of palm kernel oil. Palm kernel meal samples were prepared and treated with different enzymes prior to extraction. The oil was then extracted using a water floatation method. Treatments with a crude enzyme with both cellulase and a hemicellulase activities, only or in combination with a protease and a pectinase, all resulted in higher palm kernel oil yield than control treatments. Optimum yield occurred when a protease, a pectinase and the cellulase/hemicellulase enzymes were combined, each at 1% concentration. Yield was influenced by the pH of the meal suspension and the meal/water ratio during the enzyme treatment. The former seemed to affect the free fatty acid values of the enzyme-assisted extracted palm kernel oil. The observations suggested that the enzyme-assisted aqueous extraction method could be used to improve the viability of the traditional palm kernel oil process.

**Key words:** aqueous extraction, enzyme-assisted, palm kernel oil.

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### INTRODUCTION

Palm kernel oil is a co-product of palm oil and the two products are derived from fruits of the oil palm, *Elaeis guineensis*, Jacq. It is one of the two traditional commercial lauric oils, the other being coconut oil (ANONYMOUS, 1994). The numerous technical and nutritional applicability of lauric oils have made the production of these two oils important economic ventures in the world. It is reported that in 1993 over 2.94 million and 1.86 million tons of coconut and palm kernel oils, respectively, were produced globally (ANONYMOUS, 1995).

The processing of palm kernels into oil involves both rural and modern methods (TANO-DEBRAH and OHTA, 1995a). In most larger scale modern industries, high pressure operated expellers are used to squeeze out the oil, after prior preparations. The oil is then filtered to remove contaminants. A number of authors, including MOORE (1973), CORNELIUS (1983), and HAMMOND and SMITH (1986), have described the detailed process. In others also pre-pressed solvent extraction is done for more efficiency. Extraction rates in the modern processes range from about 80 to 95% of the extractable oil (CORNELIUS, 1983). The rural processes, which involve aqueous processes, however account for most of the palm kernels produced in many developing countries (TANO-DEBRAH, 1992; ADDO CONSULTANTS, 1989). In

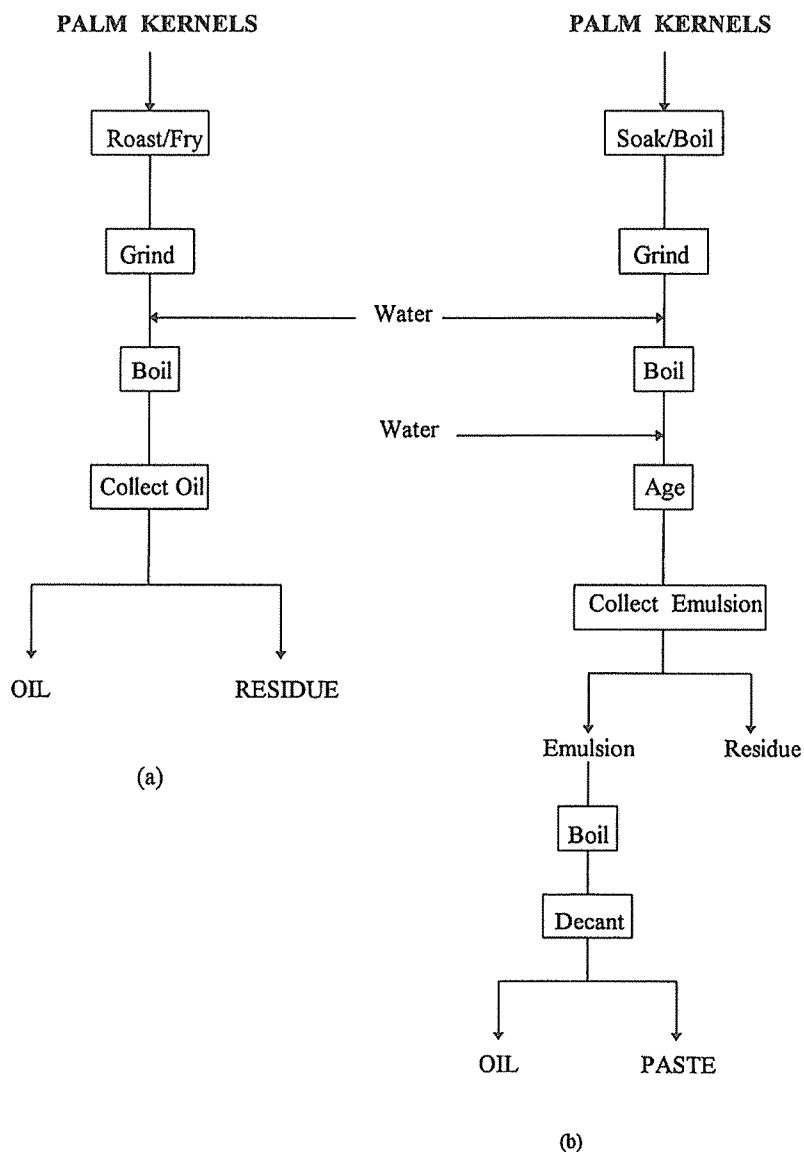


Fig. 1 Flow charts of the traditional palm kernel oil process in Ghana: (a) the roasted kernel process; (b) the unroasted kernel process.

Ghana, the methods used in traditional palm kernel processing generally fall into two types (Fig. 1) and they account for over 60% of palm kernels produced in the country (ADDO CONSULTANTS, 1989). The types are, the roasted kernel method, in which the kernels are roasted until fragile to facilitate milling, and the unroasted kernel method in which the kernels are milled without roasting (kernels may be boiled before milling) (IRVINE, 1970; ATA, 1970; CORNELIUS, 1983; UNIFEM, 1987; ADDO CONSULTANTS, 1989; TANO-DEBRAH, 1992). Generally the traditional methods are not efficient, particularly the unroasted process, with reported extraction rates of 20 to 40%, and quite often yield products of poor quality char-

acteristics. The roasting method also usually yield unbleachable dark products (STORK, 1960; HOWART, 1975; JAYALEKSHMY and MATHEW, 1991) which have fewer applications. Apparently therefore, large quantities of palm kernel are wasted yearly from the rural processes; and it is expected to increase with the increases in the production of oil palm.

The following work was done to exploit the use of enzymes in traditional palm kernel processing to improve upon the rural extraction rates. Earlier works in our laboratory have indicated the possibility of using enzyme pre-extraction treatments to improve upon some rural processes for shea fat (TANO-DEBRAH and OHTA, 1994, 1995a), cocoa fat (TANO-DEBRAH and OHTA, 1995b) and copra oil extraction (TANO-DEBRAH and OHTA, 1996b). The techniques involved were applied to the extraction of palm kernel oil for observations.

## MATERIALS AND METHODS

### *Materials and sample preparation.*

Palm kernels were obtained from Ghana. The proximate composition was determined as previously described (TANO-DEBRAH and OHTA, 1994). They were milled to pass through a 1 mm mesh, using a laboratory Wiley-type mill. The resulting meal was cool-dried and re-milled with a high speed mixer, the Sanyo Food Factory (model SKM 1550 EK; Sanyo Electric Co. Ltd., Osaka Japan), into a relatively finer meal. Samples of this was used in the oil extraction studies. The enzymes used were crude preparations obtained from Shin Nihon Chemicals. They were: Sumizyme LP, Sumizyme-C, and Sumizyme AP2. The producers information on them are shown in Table 1.

### *Enzyme-assisted oil extraction.*

Weighed quantities (about 100 g) of palm kernel meal were mixed with water, boiled, cooled and treated with enzymes as previously described (TANO-DEBRAH and OHTA, 1994, 1995a, 1995b; TANO-DEBRAH et al., 1996a). The enzymes were combined as shown in Table 3. Each enzyme was added at 1% rate of the meal. Initial meal/water ratio and pH were 1:4 and the unmodified pH of the aqueous mixtures of the meals, respectively. Incubation was done at 37°C for about 6 hours. Control set-ups of no treatment and treatment without enzymes were also done, as described in our previous reports. The treated meals were typically extracted using the hot water floatation method (TANO-DEBRAH and OHTA, 1995a).

### *Effects of enzyme treatment conditions.*

The effects of pH and meal/water ratio on the extraction rate and FFAs of the extracted oil were, here also, investigated. The meal/water ratios in this case were 1:1, 1:2, 1:4 and 1:6. All other treatment conditions were similar.

Table 1. Producer's Information on the Crude Enzymes<sup>a</sup>

Enzyme	Commercial name	Source	Specified Contaminants	Specific activity (units/gram)
Neutral protease	Sumizyme-LP	<i>A. oryzae</i>	—	50,000
Cellulase/ hemicellulase	Sumizyme-C	<i>T. reesei</i>	—	1,500
Pectinase	Sumizyme-AP <sub>2</sub>	<i>A. niger</i>	Cellulase, hemicellulase	2,000

<sup>a</sup> A. = *Aspergillus*; T. = *Trichoderma*

Table 2. Proximate Composition of the Palm Kernel Meal

Constituent	g/100 g material <sup>1</sup>
Moisture	5.24 ± 0.1
Crude fat	53.97 ± 1.4
Crude protein	8.12 ± 0.5
Ash	1.88 ± 0.1
Crude fibre	8.28 ± 1.3
Carbohydrates (by difference)	27.75 ± 2.5
Cellulose	4.65 ± 1.5

<sup>1</sup> Solid constituents were on dry matter basis.

## RESULTS AND DISCUSSION

The proximate composition (Table 2) showed high levels of crude fat, protein, fibre and cellulose. Values of crude fat content within the range of 40–55% have been reported in various literatures. DÜSTERHÖFT *et al.* (1991, 1992) and DÜSTERHÖFT *et al.* (1993) reported a negligible starch content of about 0.1%. They also indicated mannans, cellulose and xylan as the major non-starch polysaccharides of the palm kernel meal. The information obtained on the chemical composition suggested the type and combinations of enzyme used in the oil extraction study (Table 3).

The enzymatic pre-treatment of the palm kernel meal prior to extraction increased the oil yield significantly ( $p \leq 0.05$ ), (Table 3). Increases of about 50 to 75 % relative to the controls were observed. The percentage increase is expected to be higher when the values are compared to values in the traditional processes. The highest yield increase was observed when pectinase was used in addition to the cellulase/hemicellulase and protease. This may be related to the chemical composition. DÜSTERHÖFT *et al.* (1993) observed 20–50% hydrolysis of palm kernel cell wall materials (CMW) on treatment with a multi-component polysaccharidase preparation. They reported that the solubilization of the CMW by the enzymes was determined by the cellulolytic, mannanolytic and arabinolytic activities of the enzymes. This suggests an important role of hemicellulases in the enzymatic treatment of palm kernel meal.

Table 3. Effect of enzyme treatment and enzyme type on palm kernel oil yield

Enzyme	Yield (%)	FFA (%)
Control 1	35.71 ± 3.0	3.0
Control 2	41.85 ± 2.2	3.2
HC	54.95 ± 0.7	3.1
Pr + HC	60.88 ± 0.6	3.3
Pr + HC + Pe	62.51 ± 0.4	3.4

Control 1, a replicate of the basic traditional process; Control 2, meal was treated without enzymes; HC, enzyme with both cellulase and hemicellulase activities; Pr, protease; Pe, pectinase.

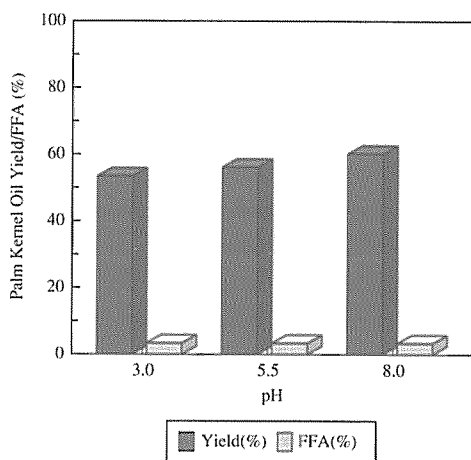


Fig. 2 Effect of pH on the yield and free fatty acid levels of palm kernel oil in an enzyme-assisted extraction.

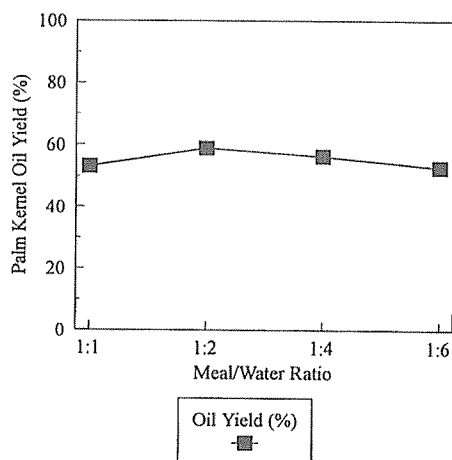


Fig. 3 Effect of meal/water ratio on the yield of palm kernel in an enzyme-assisted extraction.

Generally the studies by DÜSTERHÖFT *et al.* (1993) may also partly explain the low extraction rates here, compared to the rates in the enzyme-assisted extraction of shea fat or cocoa fat as we had observed. But another factor which might have contributed to the lower increases in yield here was the effect of particle size. It was not possible to obtain a more finer palm kernel meal with the type of mill used. The crystalline nature of the palm kernel endosperm made the hammer-mill type of equipment used inefficient. Traditional processors usually use double plate disc-attrition mills, and most of them also resort to roasting to facilitate fine milling.

The effects of pH and meal/water ratio on the palm kernel yield are shown in Figs. 2 and 3. Both factors significantly influenced the yield. Yield increased with increasing pH, and in the range tested, the highest yield occurred at pH 8. Similar trend of the pH effect was observed in the enzyme-assisted extraction of the shea fat, cocoa fat and coconut oil (TANO-DEBRAH and OHTA, 1995a, 1995b and 1996b). The effects of meal/water ratio also followed the pattern we had earlier on reported. The optimum dilution was about 1:2. Beyond this, yield values decreased. Fig. 2 also shows data on the effect of treatment pH on the free fatty acid values (FFA) of the fat extracted. Apparently the more acidic condition had some deteriorative effect on the oil. The pH of the palm kernel meal suspension was 5.3–5.5. Thus, the unmodified palm kernel oil suspension pH seems to be adequate for the enzymatic treatment.

It could be concluded from the study that, the pre-extraction enzyme treatment of palm kernel meal could significantly improve upon the extraction rates of the rural aqueous unroasted kernel process. The technique, if applied may consequently help to increase the viability of the palm kernel oil industry in many developing countries. The study has also demonstrated a wider applicability of the enzyme-assisted aqueous extraction method explored in shea fat extraction.

## REFERENCES

- ADDO CONSULTANTS, 1989. *A study of the Oil Palm Industry in Ghana*. J.S. Addo and Consultants, Opeibea House, Accra.
- ANONYMOUS, 1994. Lauric Oil Sources: some old, some new. *INFORM* 5: 144–149.
- ANONYMOUS, 1995. Palm oil update. *INFORM* 6: 884–890.
- ATA, J.K.B.A. (undated). *Quality Characteristics of some Industrial and Traditional Palm Kernel Oil in Ghana*. Official Document, Food Research Institute (FRI), CSIR, Accra, Ghana.
- CORNELIUS, 1983. *Processing of Palm fruits and its products*. Tropical Products Institute, GA 149.
- DÜSTERHÖFT, E-M, A.G.J. VORAGEN and F.M. ENGELS, 1991. Non-starch Polysaccharides from Sunflower (*Helianthus annuus*) Meal and Palm Kernel (*Elaeis guineensis*) Meal- Preparation of Cell Wall Material and Extraction of Polysaccharide Fraction. *J. Sci. Food Agric.* 55: 411–422.
- DÜSTERHÖFT, E-M., M.A. POSTHUMUS and A.G.J. VORAGEN, 1992. Non-starch Polysaccharides from Sunflower (*Helianthus annuus*) Meal and Palm Kernel (*Elaeis guineensis*) Meal- Investigation of the Structure of Major Polysaccharides. *J. Sci. Food Agric.* 59: 151–160.
- DÜSTERHÖFT, E-M, A.W. BONTE and A.G.J. VORAGEN, 1993. Solubilization of Non-starch Polysaccharides from Oil Seed Meals by Polysaccharide-degrading Enzymes. *J. Sci. Food Agric.* 63: 211–220.
- HAMMOND, T.W. and A.C. SMITH, 1986. *An industrial profile of small scale vegetable oil expelling*. TDRI Report G.202. Tropical Development and Research Institute.
- HARTLEY C.W.S., 1984. *The Oil Palm*. 2nd edn, Longmans, London, New York.
- HOWART, G.R., 1975. Development in the edible oil industry in West Africa. *Proceedings: Food Industry in West Africa*. Dept. of Nutrition and Food Science, University of Ghana, Legon Accra.
- IRVINE, F.R., 1970. *West African Agriculture*. 3rd edn, Oxford University Press.
- JAYALEKSHMY, A and A.G. MATHEW, 1991. Effect of roasting on the lipids, sugars and amino acids of palm kernel. *Oleagineux* 46: 163–168.
- MOORE, E., 1973. *Vegetable Oils and Fats. Their production and commercial extraction*. A Unilever Educational Booklet; Revised Ordinary Series No. 2; Unilever Ltd., England.
- STORK, G., 1960. Sterilization. *Stork Palm Oil Review* 1: 6
- TANO-DEBRAH, K., 1992. *Traditional Palm kernel oil processing in Ghana: Process and product characteristics*. M.Phil. Thesis University of Ghana, Legon-Accra.
- TANO-DEBRAH, K. and Y. OHTA, 1994. Enzyme-assisted aqueous extraction of Fat from Kernels of the Shea tree, *Butyrospermum parkii*. *J. Am. Oil Chem. Soc.* 71: 979–983.
- TANO-DEBRAH, K. and Y. OHTA, 1995a. Enzyme-assisted aqueous extraction of Shea Fat: A rural approach. *J. Am. Oil Chem. Soc.* 72: 251–256.
- TANO-DEBRAH, K. and Y. OHTA, 1995b. Application of enzyme-assisted aqueous fat extraction to Cocoa fat. *J. Am. Oil Chem. Soc.* 72: 1409–1411.
- TANO-DEBRAH, K., Y. YOSHIMURA, and Y. OHTA, 1996. Enzyme-assisted extraction of Shea fat: Evidence from light microscopy on the degradative effects of the enzyme treatment on cells of the Shea kernel. *J. Am. Oil Chem. Soc.* 73: 449–453.
- TANO-DEBRAH, K. and Y. OHTA, 1996b. Aqueous Extraction of Coconut Oil by an Enzyme-Assisted Process. *J. Sc. Food Agric.* (In press).
- UNITED NATIONS DEVELOPMENT FUND FOR WOMEN (UNIFEM), 1987. *Oil extraction, Food Cycle Technology Source Books*, UNIFEM, New York.

## 酵素のパーム核油の水抽出への応用

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パーム核油の水抽出に酵素を応用した。パーム核を粉碎し, 色々な酵素で, 水浮遊法でパーム核油を抽出した。粗酵素のセルラーゼとヘミルラーゼまたは, さらに, プロテアーゼとペクチナーゼを同時に作用させると油の回収率が高くなった。それぞれの酵素を1%ずつ用いた場合が最高の収率になった。また, 収率はpH及び粉碎物と水との混合割合によって影響された。pHは回収された油中の遊離脂肪酸の値に影響した。この酵素法で伝統的なパーム油の製造法を改良出来ることが分かった。

キーワード: 水抽出、酵素法、パーム核油