OPTIMUM PASTE TEMPERATURE FOR OIL EXTRACTION USING IAR MOTORISED KNEADER

Gyuse, E.T. [1] and Yiljep, Y.D.[2]

Abstract

An experiment to determine optimum paste temperature for oil extraction using the Institute for Agricultural Research (IAR) motorised kneader was conducted at the Agricultural Engineering Department of Ahmadu Bello University Zaria, in 2002. Some 20 kg of groundnut paste from the *Manipinta* variety (locally known as *Kampala*) with 55% oil content at 5 - 6% moisture content was used for the experiment. The paste was divided into five equal replicates (of 4kg each) for use with motorised kneader. Results show that IAR motorized kneader enhanced extraction efficiency at low values of paste temperatures. Optimum extraction efficiencies of 88.31 – 98.55% were obtained at paste temperature of 23.50 – 25.00°C, corresponding to atmospheric and added water temperatures of between 15.75 – 23.09 and 22.00 – 26.00°C, respectively. It is therefore recommended that groundnut paste at elevated temperature be allowed to cool to about 24.50°C before kneading. The optimum extraction efficiency of the kneader was realized at room temperature during the harmattan season.

1. Introduction

Groundnut is a source of highly nutritious food for both humans and livestock. The uses to which the crop is put are many, and its importance is steadily increasing. As human food, the kernel is consumed raw, salted or roasted and is used in various forms of confectionary; the oil is excellent for margarine manufacturer (Ker *et al.*, 1957 as cited by Ola, 2000).

Oil processing is a lucrative business due to the enormous demand for oil, both for domestic and industrial uses (Pirie, 1975). Moreover, in some parts of Africa such as Nigeria and Ghana, oil extraction and marketing have become a source of income to many people. Extraction of vegetable oils from the oil-bearing materials dates back many ages. It was developed in China and India probably much earlier than in other parts of the world. Whereas the old Chinese oil processes used in remote villages of Manchuria were driven by manpower, in India, the primitive village Ghanis was driven by bullocks and in their absence by manpower (Parek, 1964).

According to Adeeko and Ajibola (1990), groundnut oil extraction is affected by factors such as paste temperature, speed of the oil extraction machine, temperature of water used, atmospheric temperature, machine processing time, feed rate, amount of water used, particle size of oil seeds and moisture content of oil seed.

Head *et al.* (1995) stated that higher processing temperatures improve oil flow by reducing the viscosity of the oil. According to them, small-scale expeller minimizes the

[1]Department of Agric. Engineering and Technology, Samaru College of Agriculture, Ahmadu Bello University, Zaria. Nigeria
[2]Agricultural Engineering & Irrigation Programme, National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Zaria. Nigeria.

need for pre-treatment by using a relatively fast worm shaft speed which shears the oil seed as it passes through the expeller and produces frictional heat within the expeller barrel. This assists oil expulsion by raising the temperature of the oil seed. However, even when using a small-scale expeller, heating and/or steaming the oil seed before expelling will assist oil extraction. Heat treatment is essential for some seeds with low fibre content such as groundnut; they must be heated and moisturized before expelling or the machine will produce an oil paste of oil and cake.

With the oil press machines, Head *et al.* (1995) stated that until the barrel reaches the operating temperatures, a large amount of sediment 'foots' might be produced with the oil. Hui (1996) reported that in oil pressing plants, the seed is subjected to extreme heat and pressure and oil is mechanically forced out from the oil cell.

According to UNIFEM (1993), in traditional oil extraction, the paste is heated first, and then with water the mixture is stirred and allowed to boil. After boiling, the mixture is allowed to cool, during which time the oil gathers at the top and is scooped off. Extraction efficiency with this method is about 40%.

Williams (1966) established that solvent extraction of oil from oil seeds generally involves washing out of the oil from the ground seed by means of a hot (or raised temperature) solvent and its subsequent evaporation in order to recover the dissolved oil. The extraction meal is freed from solvent by heating and finally by steaming and the remaining traces are distilled from the meal until the latter is completely freed from any smell of solvent.

The objective of this study was to determine water and paste temperatures that produce the highest oil yield from IAR motorized paste kneader.

2. Materials and methods
2.1. The Kneader
Description
The IAR Kneader is a motorized kneader powered by an electric motor. The top of kneader chamber through which the oil material is fed is 355 mm in diameter while the bottom is 190 mm in diameter. The height of the kneading (bucket) chamber is 570 mm, and that of the finger-like kneading mechanism is 320 mm. The height of the shaft holding the fingers is 690 mm. The clearance between the bottom of the kneading chamber and the lower end of the kneading fingers is 10 mm, while that between the walls of the chamber and the fingers is 20 mm. The fingers are inclined at angle of 30° to the shaft.

Principle of Operation
The kneader expresses oil from groundnut paste by using a metal with a power driven finger-like shaft fixed to a metal frame. With the IAR kneader, little or no heat is developed in the course of kneading since the extraction chamber is an open bucket. Oil extraction is accomplished by kneading. The groundnut paste is fed into the mortar, and as the power driven finger-like shaft rotates, it stirs the paste and coagulates it when

warm water is added. The oil released is collected through a 30 mm diameter pipe at the bottom of the mortar.

2.2 Data Collection

Manipinta (locally known as Kampala) was the available groundnut variety at the time of this experiment. It was obtained at the Samaru market in Zaria, Kaduna State, Nigeria. Its oil content is 55% at 5 – 6% moisture content. The groundnut was ground at Agricultural Engineering Department of Ahmadu Bello University, Zaria with a pepper grinding machine and the kneading experiment was carried out in the same Department.

Twenty kilograms of the groundnut paste was divided into five equal parts and the kneading machine was used on the five samples. Factors such as speed of kneading fingers, feed rate, time of kneading and water used in kneading were assumed constant.

Ambient temperatures, that of the paste before kneading, water temperature were measured using a dry bulb thermometer. Oil yield and water used were measured using a measuring cylinder, whereas machine extraction efficiency was calculated using the Equation *1* below.

$$Eff = (\frac{W1}{W2})x100\% \hspace{3cm} 1$$

where *Eff* = Oil extraction efficiency (%)
      W1 = Weight of oil extracted (kg)
      W2 = Weight of paste kneaded (kg)

3. Results and discussion

Data collected from the use of the kneader are presented in Table 1. It can be seen from the table that the extraction efficiency of the kneader decreased with increasing paste temperatures. At lowest temperatures of paste (31.50^{o}C), water (28.00^{oC}) and atmosphere (28.50^{o}C), the kneader extraction efficiency was 50.20%. The extraction efficiency decreased to 41.13% at higher temperatures of 32.95^{o}C, 28.90^{o}C and 31.60^{o}C of paste, water and the ambient surrounding, respectively.

Table 1: Data collected from the use of the kneader

Sample	T_p * (^{o}C)	T_w (^{o}C)	T_a (^{O}C)	W_e (kg)	W_f (kg)	*Eff* (%)	*t* (min)
A	31.50	28.00	28.50	1.20	1.10	50.20	27.00
B	31.80	28.20	29.40	1.15	1.05	47.99	27.20
C	32.50	28.60	30.50	1.20	1.00	45.70	24.06
D	32.95	28.90	31.60	1.10	0.90	41.13	28.00
E	32.98	29.10	32.10	1.10	0.95	43.42	26.25
Mean	32.34	28.56	30.42			45.69	
St. dev	0.67	0.46	1.50			3.59	

*T_p – temperature of paste, T_w – temperature of water, T_a – ambient temperature, W_e – weight of extracted oil, W_f of oil after frying, *Eff.* – extraction efficiency, *t* – oil frying time

Figure 1 shows that elevated temperatures of paste decreased the extraction efficiency of the kneading machine. At about 0^oC of paste temperatures, the kneader did not function properly since the paste tended to block up. The operational and optimum paste temperature is between 23.50 and 25^oC. This range corresponds to the kneader extraction efficiency range of $88.31 - 98.55\%$.
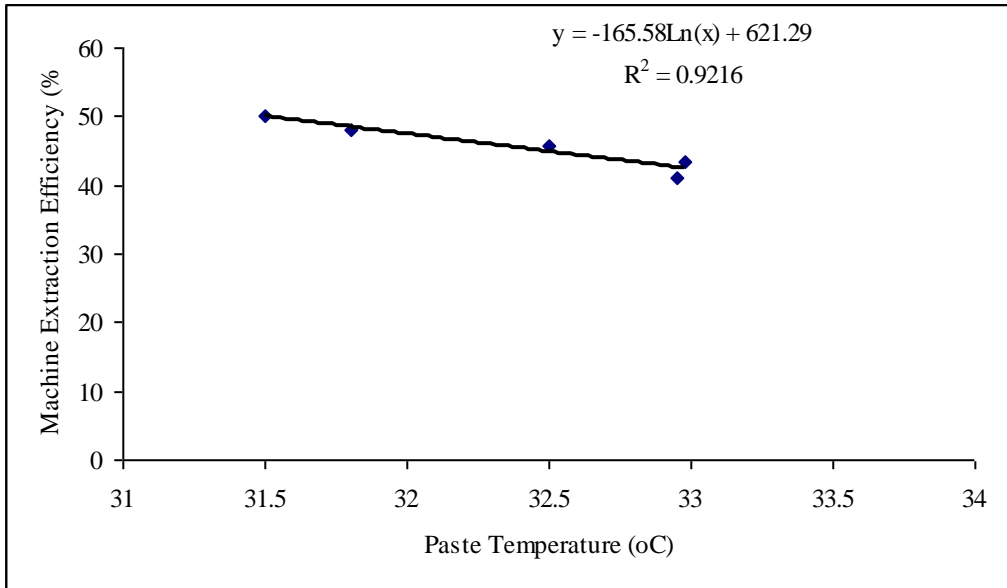

Figure 1: Machine extraction efficiency versus paste temperature

Elevated ambient temperatures decreases the kneader extraction efficiency and vice versa (Figure 2). Ambient temperature affects paste temperatures and eventually kneader extraction efficiency. Temperatures of water used in kneading also inversely affected paste temperatures and the kneader extraction efficiency. Increasing the water temperatures above 35^oC decreased the efficiency (Figure 3).
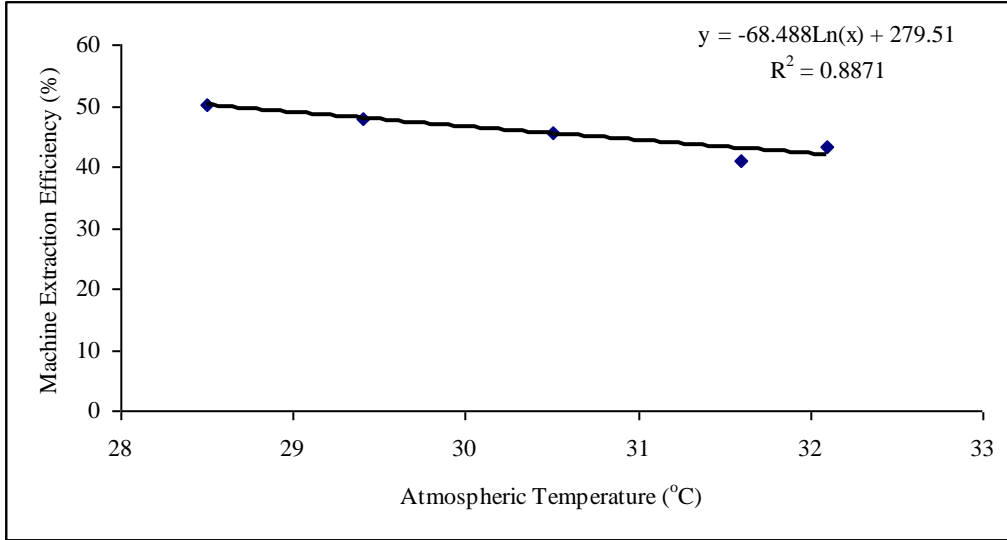
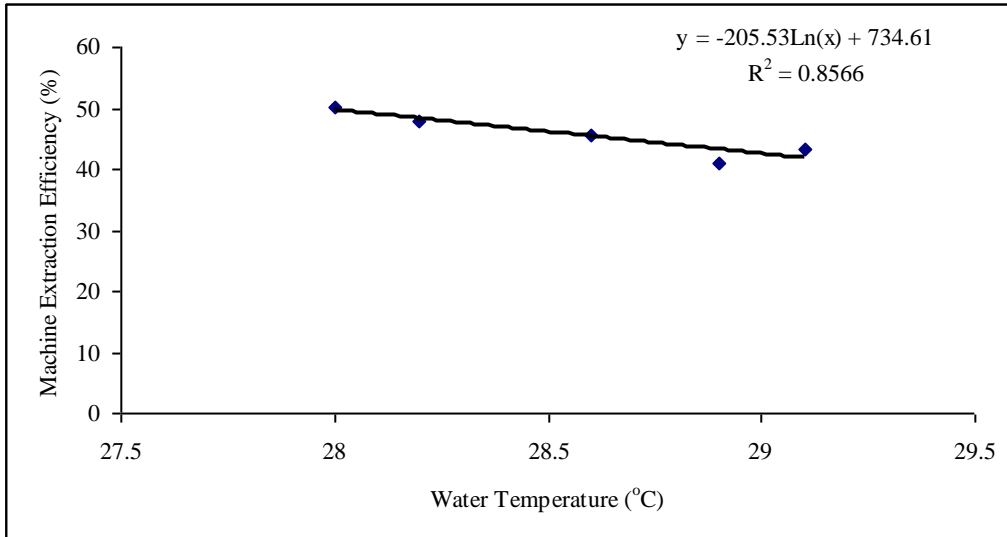**Figure 2: Machine extraction efficiency versus atmospheric temperature**

Figure 3: Machine extraction efficiency versus water temperature

Paste and water temperatures vary with ambient temperatures provided no external heat is applied. Figure 4 shows that temperatures of water and paste increase with increase in ambient temperature and vice versa. When optimum paste temperature T_p is between 23.5 and 25°C (Figure 1), the atmospheric temperature (T_a) can be estimated from Equation *2*, and when optimum water temperature T_w is between 22 and 26°C (Figure 3) the atmospheric temperature (T_a) can be estimated from Equation *3*:
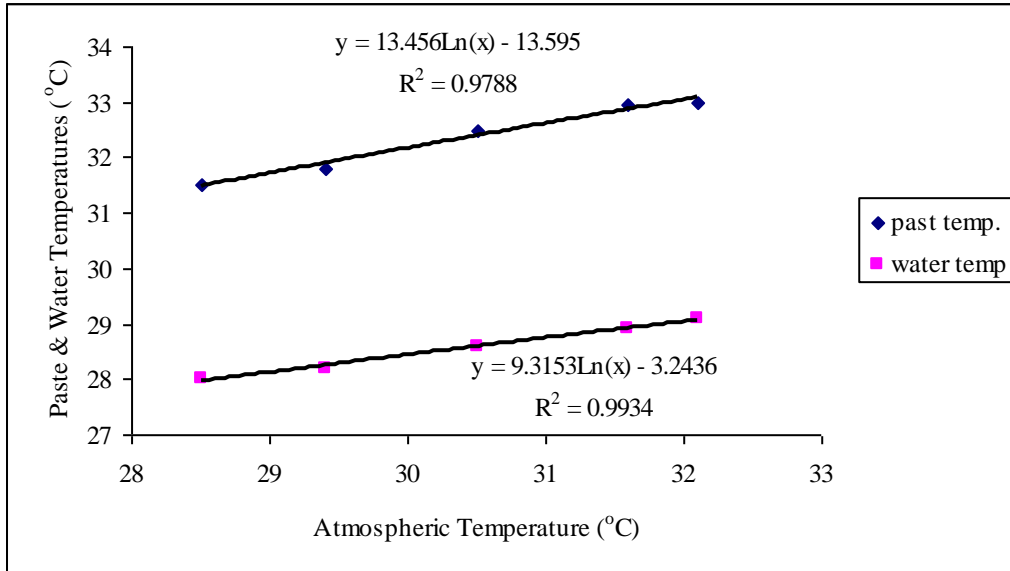
Figure 4: Water and paste temperatures versus atmospheric temperature

$$T_a = e^{P(+13.595/13.456}$$
<div style="text-align: right;">*2*</div>

$$T_a = e^{Wt+3.2436/9.3153}$$
<div style="text-align: right;">*3*</div>

Adding warm water (at $26^{\circ}C$) at ambient temperature decreases paste temperature as shown in Figure 5, and this is favourable for oil extraction.
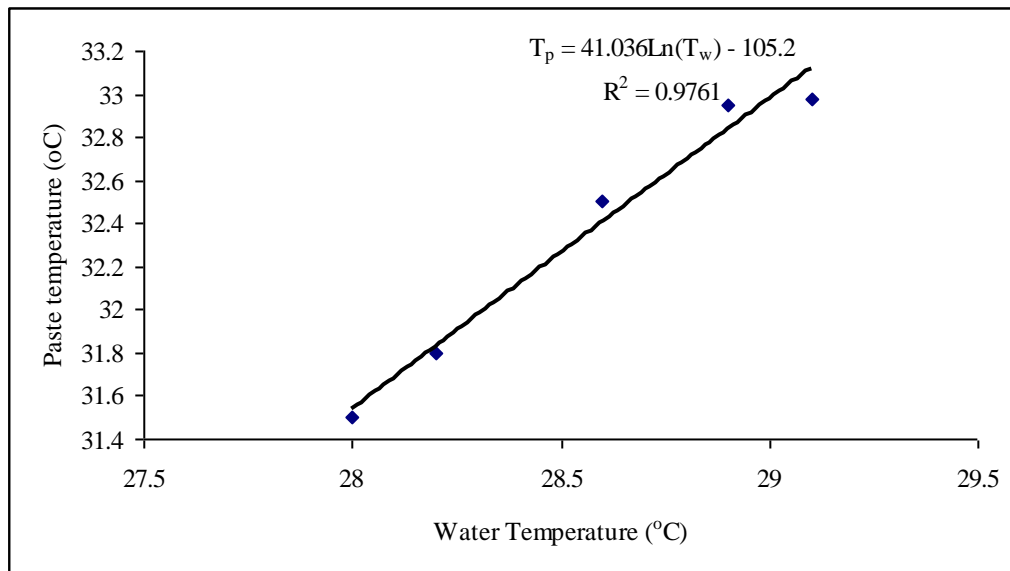

Figure 5: Water temperatures versus paste temperature

4. Conclusion

It was observed that at reduced temperatures of paste, the motorized kneader extraction efficiency was enhanced. With the kneader optimum extraction efficiency is 88.31 – 98.55%, the corresponding paste, water and ambient temperatures were in the ranges of: 23.5 – 25°C, 22 – 26°C and 15.75 – 23.09°C respectively. This means that groundnut paste brought from the mill at elevated temperatures should be allowed to cool before kneading, which is in line with the recommendation of UNIFEM (1993) for traditional oil extraction.

Moreover, during kneading, the temperature of the water added to the paste should be within the range mentioned above. The temperature of the surroundings should also be within the range mentioned above since paste temperature varies with that of the surroundings if no external heat is applied.

References

Adeeko, K.A. and O.O. Ajibola (1990). Processing factors affecting yield and mechanically expressed ground-nut oil. *J. Agric. Engr. Res.* **45**:31-43.

Gyuse, E.T. (2004). *Comparative analysis of selected groundnut extractors*. Unpublished M.Sc. Thesis, Agricultural Engineering Department Ahmadu Bello University, Zaria.

Head, S.W., T.W. Hanmonds, A.A. Swetman and R.V. Harris (1995). Small-scale oil extraction. Natural Resources Institute NRI Britian Pp 20-39.

Hui, Y.H. (1996). Edible Oil and Fat Products: Processing Technology, In Bailey (ed). *Industrial Oil and Fat Products* 5th Ed. John Wiley and Sons New York Pp. 10, 11.

Ola, F.A.(2000). *Development of a motorized ground-nut oil extractor*. Unpublished M.Sc. Thesis, Agricultural Engineering Ahmadu Bello University Zaria.

Parek, H.V. (1964). Solvent extraction of vegetable oils, 2nd Ed. In Patel (ed). *Indian Central Oils Seeds Committee "Techan Bharan"* Pp 1-10

Pirie, N.W. (1975). *Food protein sources*. Cambridge University Press Cambridge London New York Melbourne. 1st Ed. Pp. 19.

UNIFEM (1993). United Nations Development Fund for Women. Oil processing *Intermediate Technology Publications*, No. 2.

Williams, K.A. (1966). *Oils, Fats and Fatty Foods*, 4th Ed. J & A Churchill Ltd, 104 Gloucester Place London W. 1 Pp 190 -195.