SURFACE TENSIONS OF PALM OIL, PALM OLEIN AND PALM STEARIN

Keywords: Surface tension; Palm oil; Palm olein, Palm stearin.

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The surface tensions of palm oil, palm olein and palm stearin against air were measured using a Kruss Digital Tensiometer. Measurements were carried out from 293.2°K to 453.2°K. Determinations were made on twenty samples of each of the three products and the values obtained were between 33.2 and 22.6 mN/m at 293.2°K and 453.2°K respectively. The surface tensions decrease linearly with increasing temperature.

INTRODUCTION

Palm oil has a wide range of applications and it is commonly fractionated into olein and stearin. The different properties of palm oil and its fractions allow the products to be used for different purposes. However there is a lack of data on the fundamental physical parameters of palm oil and its fractions, and in this paper we report the measurement of the surface tensions. These are then compared with those of cottonseed, castor and coconut oils as reported by Formo (1979). Surface tension data can be useful for various applications, *e.g.* in process control and in developing product formulations.

EXPERIMENTAL

A Kruss Digital Tensiometer Model K10T was used in this study (Kruss, 1980). It has a sample holder whose temperature can be controlled between 283.2° K and 353.2° K through an external thermostatted circulating bath. Sample temperature was measured with a digital thermometer which was calibrated against a standard thermometer.

Measurements were carried out on samples of production palm oil, single fractionated palm olein and palm stearin. The samples were melted at 343.2° K, 333.2° K and 353.2° K respectively and the melted samples were filtered hot in an oven set at 333.2° K. The surface tension measuring ring was thoroughly cleaned and heated to redness before use (Kruss, 1980).

Each measurement was carried out in two stages. Stage One was for temperatures between 293.2° K

TABLE 1. REPRODUCIBILITY OF SURFACE TENSION (mN/m) OF PALM OIL AGAINST AIR
(sample measured on five different days)

Temperature (°K)	313.2	323.2	333.2	343.2	353.2	363.2	373.2	383.2	393.2	403.2	413.2	423.2	433.2	443.2	453.2
Measurement															
1	31.5	30.9	30.0	29.7	28.8	28.4	27.8	27.1	26.5	25.9	25.2	24.6	23.9	23.3	22.6
2	30.8	30.4	29.9	29.0	28.6	27.9	27.3	26.6	26.0	25.4	24.8	24.1	23.5	22.9	22.3
3	31.2	30.3	29.9	29.2	28.5	28.1	27.4	26.8	26.1	25.5	24.8	24.2	23.5	22.9	22.2
4	31.4	30.8	29.9	29.3	28.7	28.2	27.5	26.9	26.2	25.6	24.9	24.3	23.6	23.0	22.3
5	31.4	30.7	29.9	29.2	28.8	28.2	27.5	26.9	26.3	25.6	25.0	24.3	23.7	23.1	22.4
Mean	31.3	30.6	29.9	29.3	28.7	28.2	27.5	26.9	26.2	25.6	24.9	24.3	23.6	23.0	22.4
Min	30.8	30.3	29.9	29.0	28.5	27.9	27.3	26.6	26.0	25.4	24.8	24.1	23.5	22.9	22.2
Max	31.5	30.9	30.0	29.7	28.8	28.4	27.8	27.1	26.5	25.9	25.2	24.6	23.9	23.3	22.6
S.D.(%)	0.25	0.23	0.04	0.23	0.12	0.16	0.17	0.16	0.17	0.17	0.15	0.17	0.15	0.15	0.14

TABLE 2. SURFACE TENSIONS (mN/m) OF PALM OIL, PALM OLEIN AND PALM STEARIN AGAINST AIR (mean of 20 samples each)

Temperature (°K)	Product		
	Palm Oil	Palm Olein	Palm Stearin
293.2	N.A.	33.2	N.A.
303.2	32.4[a]	32.7	N.A.
313.2	31.9	32.1	32.0[b]
323.2	31.2	31.5	31.2[c]
333.2	30.6	30.8	30.5
343.2	30.0	30.1	29.9
353.2	29.3	29.5	29.2
363.2	28.6	28.7	28.4
373.2	27.9	28.0	27.7
383.2	27.2	27.4	27.1
393.2	26.6	26.7	26.5
403.2	25.9	26.1	25.8
413.2	25.3	25.4	25.2
423.2	24.6	24.7	24.5
433.2	24.0	24.1	23.9
443.2	23.3	23.4	23.2
453.2	22.7	22.8	22.6

Notes :
N.A. = Not applicable
[a] Mean of 14 samples: the other six samples started to crystallize
[b] Mean of four samples: the other 16 samples started to crystallize
[c] Mean of 17 samples: the other three samples started to crystallize

TABLE 3. SURFACE TENSIONS (mN/m) OF SOME VEGETABLE OILS

Temperature (°K)	Coconut[a] Oil	Palm[b] Stearin	Palm[b] Oil	Palm[b] Olein	Cottonseed[a] Oil	Castor[a] Oil
293.2	33.4	N.A.	N.A.	33.2	35.4	39.0
353.2	28.4	29.2	29.3	29.5	31.3	35.2
403.2	24.0	25.8	25.9	26.1	27.5	33.0

Note: [a] from Formo (1979)
[b] from this study
N.A. Not applicable

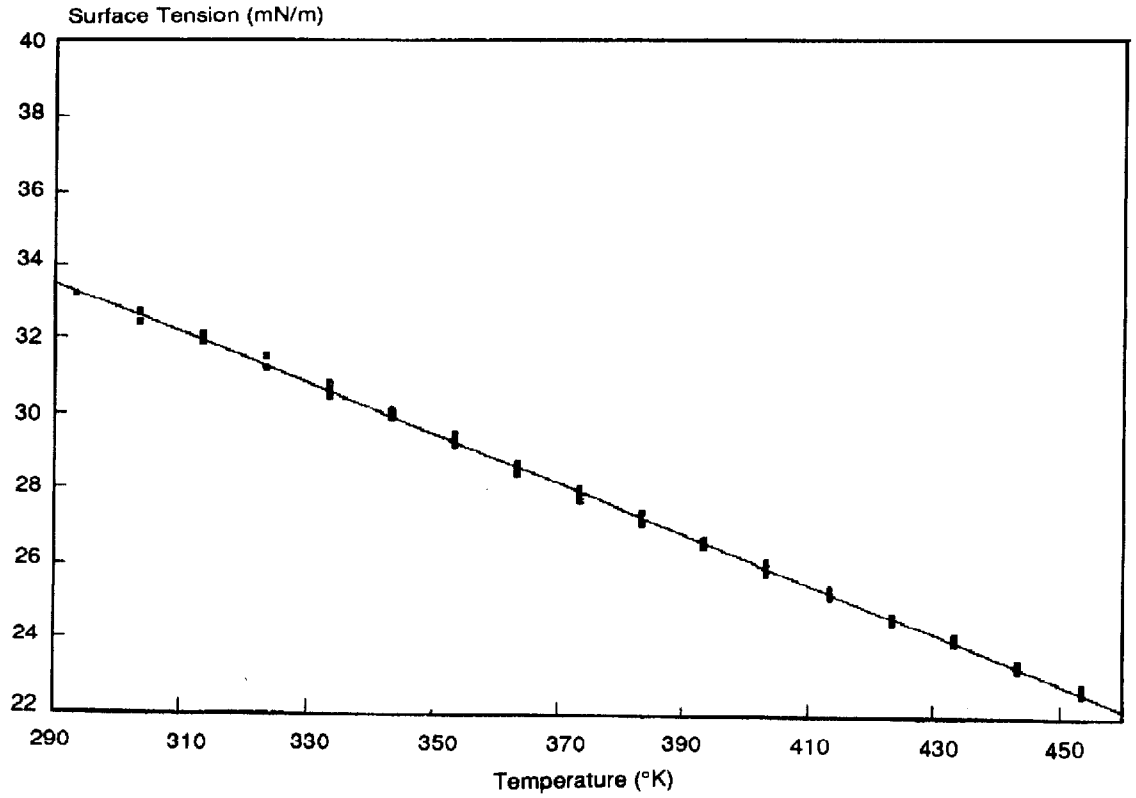

Figure 1. Surface Tension of Palm Oil, Palm Olein and Palm Stearin considered together.

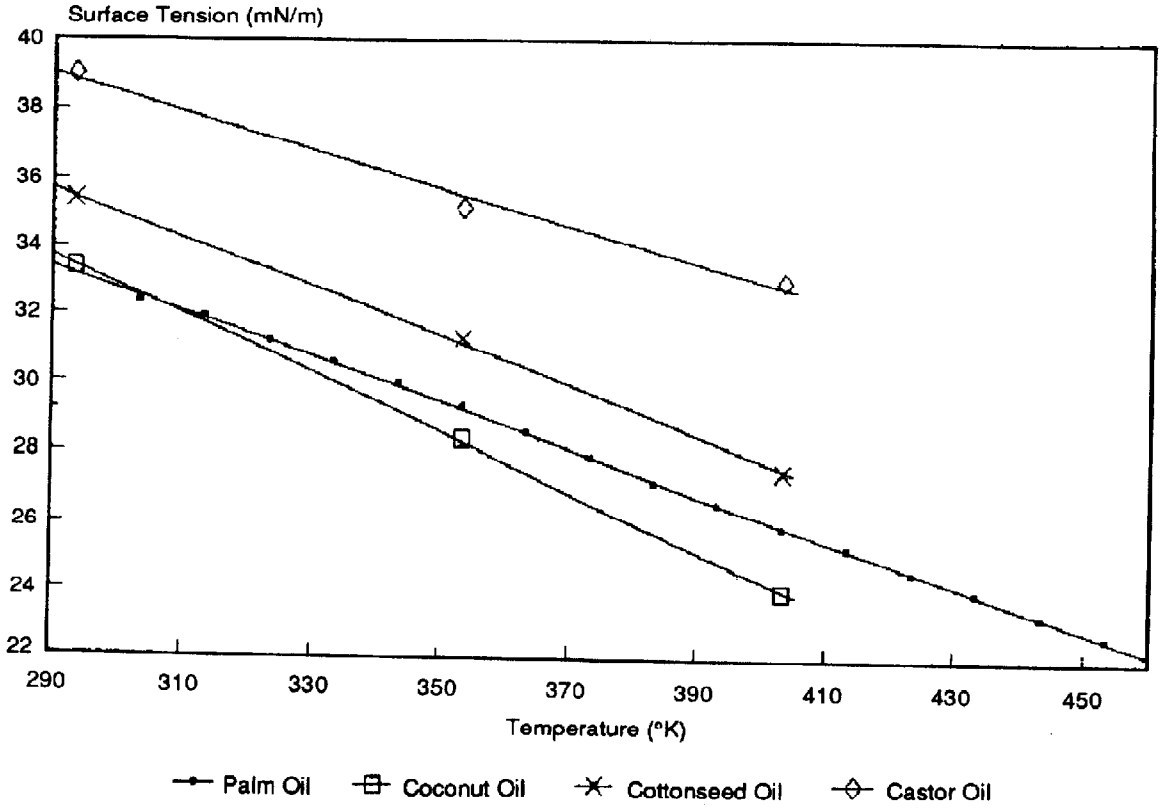

Figure 2. Surface Tensions of some Vegetable Oils.

Note: Data on palm oil from this study, on other oils from Formo (1979)

and 353.2° K and Stage Two for temperatures between 363.2° K and 453.2° K.

For Stage One, the sample was remelted at the given temperature and then kept for 30 min. in an aluminium tempering block pre-equilibrated at the desired measuring temperature in a thermostatted bath. The tempered sample was then transferred to the sample holder of the tensiometer for measurement. The holder was also pre-equilibrated at the same temperature. Three measurements were made on each sample and the average was reported.

For Stage Two the sample was heated to 463.2° K and immediately transferred to the sample holder. The holder was kept at 353.2° K. Both the surface tension and the temperature of the sample were recorded as it cooled. Measurements were stopped at 358.2° K. A regression equation between surface tension and temperature was obtained and the values between 363.2° K and 453.2° K were calculated at 10 degree intervals. The average of three calculated results was reported.

RESULTS AND DISCUSSION

The reproducibility of measurements on a palm oil sample is given in *Table 1*. The standard deviation was found to be between 0.04 and 0.25 and was generally below 0.17 mN/m.

If crystals were observed during tempering, no measurement was made. The surface tensions of palm oil, olein and stearin are given in *Table 2*. The results were the means of measurements on 20 samples of each type of product. The data show that the three products have similar values for surface tension over the temperature range studied. The surface tensions were found to decrease linearly with increase in temperature and the following regression equations were obtained :

for palm oil

$$ST = 52.46 - 0.0658t \quad (r^2 = 0.9997) \quad (1)$$

for palm olein

$$ST = 52.84 - 0.0664t \quad (r^2 = 0.9996) \quad (2)$$

for palm stearin

$$ST = 52.74 - 0.0667t \quad (r^2 = 0.9993) \quad (3)$$

where

ST = surface tension (mN/m)

t = temperature in °K

If the three products were considered together then an overall regression equation (*Figure 1*) was obtained:

$$ST = 52.75 - 0.0664t \quad (r^2 = 0.9986) \quad (4)$$

Equation (4) is similar to the other three equations and it could be used for approximate calculations on production palm oil, single fractionated palm olein and palm stearin. For more precise calculations the individual equations should be used.

On comparing the values obtained in this study with those reported by Formo (1979), it was observed that surface tension increased in the order: coconut oil, palm stearin, palm oil, palm olein, cottonseed oil (*Table 3*). The differences among the three palm products were however relatively small as already noted (*Table 2*). The major fatty acids of coconut, palm and cottonseed oils are lauric, palmitic and linoleic respectively, with increases in chain length from lauric to linoleic. Between palm stearin and palm olein, palm stearin has higher palmitic (*e.g.* 49%) but lower oleic (*e.g.* 35%) and linoleic (*e.g.* 9%) acids, while palm olein has lower palmitic (*e.g.* 40%) but higher oleic (*e.g.* 43%) and linoleic (*e.g.* 11%) acids. Palm oil has an intermediate composition (*e.g.* 44%, 40% and 10% of palmitic, oleic and linoleic acids respectively). From the data obtained it appears that the surface tension of an oil increases as the chain length of the major fatty acid increases, and also as its unsaturation increases. Castor oil, on the other hand has ricinoleic acid as its major fatty acid and differs from the other oils by its high gravity and viscosity, which result in its significantly higher surface tension (*Figure 2*).

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