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Essential Fatty Acid Content of Dietary Fats and Fat Rich Foods Used in Rhodesia

BY

S. H. W. CMELIK, M. R. R. BULLOCK and H. E. LEY

(*Department of Biochemistry, University of Rhodesia, Salisbury, Rhodesia*)

Since the classical experiments by Kinsell *et al.* (1952) it has been generally accepted that replacement of animal fats in the diet by certain vegetable fats results in dramatic decreases in cholesterol and phospholipid concentration in serum and consequently reduces the risk of atherosclerosis. Joliffe and Archer (1959) collected data on death-rates due to coronary artery disease from 20 countries. The death-rate was positively related statistically to the percentage of saturated fat in the diet and the percentage of animal protein intake.

In Rhodesia according to statistical reports* the death-rate from ischaemic heart diseases during 1970 was for Europeans 147, for Asians 60 and Coloureds 37 in 100 000. Most of these deaths have been caused by atherosclerotic changes. If one added to this the number of deaths listed under hypertensive and cerebrovascular disease, which are also caused by atherosclerotic lesions, the death-rate for Europeans would be well over 200 in 100 000. For Africans it is very difficult to give even approximate figures. However, from recent reports it transpires that the number of coronary deaths in Africans is on the increase, especially in the urban areas (Ross, 1969).

This high death-rate due to atherosclerotic changes is a matter of concern and would require a reappraisal of the nutritional habits. Unfortunately, no data are available on the average caloric intake and the percentage of fat in the total caloric intake which would be the best indicator for the contribution of the diet in coronary heart disease. However, from statistical reports* it could be seen that in the average European family, from the total monthly spending for dietry fats, 34 per cent. goes for butter, 9 per cent. for other animal fats, 40 per cent. for margarine and only 17 per cent. for vegetable oils. To this should be added the fat from meat and meat products of which the average European in Rhodesia consumes more than 70 kg per year. Eggs are also an important atherosclerogenic factor and the yearly average consumption per capita is about 250.

In order to obtain an idea about the possible contribution of the dietary fats in coronary heart disease in Rhodesia, it was decided to investigate the fatty acid composition and cholesterol content of the most common dietary fats and fat rich products available on the Rhodesian market. The results of this investigation could serve as a useful guideline for medical practitioners and dieticians in prescribing a cholesterol lowering diet.

Materials and Methods**

Samples

Samples of various products were obtained from various local stores and supermarkets. Preference was given to larger supermarkets with a big turnover. Samples of eggs were obtained directly from various farmers. Pure groundnut, sunflower and cottonseed oils were kindly supplied by Lever Bros. (Pvt.) Ltd. in Salisbury.

Methods

Moisture was determined in solid products by drying at 105° for 16 hours. In semi-solid products moisture was determined by distillation with xylene in a Dean and Stark apparatus.

Fat was extracted from solid products in a Soxhlet apparatus with ether. From semi-solid products fat was extracted with chloroform-methanol (2:1). After evaporation under vacuum

*Report of the Secretary for Health for the year ended 31st December, 1970.

*Report of the European Family Budget Survey in Rhodesia 1968. Central Statistical Office, Salisbury.

**The abbreviations used are: TLC=thin-layer chromatography; GLC=gas-liquid chromatography; EFA=essential fatty acids.

in a stream of nitrogen and drying, the residue was taken into chloroform and separated from the insoluble residue. Total cholesterol was determined in original samples or extracted lipids using the Liebermann-Burchard reaction.

Hydrolysis of fat samples was effected with 10 per cent. KOH in methanol under reflux for three hours. Fats with less than 1 per cent. non-saponifiable were processed directly for the recovery of fatty acids. In all other cases the non-saponifiable was separated by extraction with ether according to AOOAC standard methods (1965). The fatty acids recovered from the alkaline solution by acidification with 2N H_2SO_4 and subsequent extraction with ether were converted into methyl esters with a methanolic solution of boron trifluoride according to Metcalf and Schmitz (1961).

The fatty acid methyl esters were analysed in a Perkin-Elmer F 11 gas-chromatograph with a dual flame ionization detector. Two-m. columns (2mm. i.d.) were packed with 20 per cent. diethyleneglycol succinate on Chromosorb G AW-DMCS (80—100 mesh). The separations were carried out isothermally at 165°C with nitrogen as a carrier (40 ml. per minute). Pure methyl esters of even-numbered fatty acids (Sigma) were used as standards. Peak areas were measured with a disc integrator (Disc Instruments Inc.) coupled to the recorder and expressed as percentages.

Changes in cis-trans isomerism of the linoleic acid were studied in products which were exposed to heat either by frying or roasting. For this purpose fatty acid methyl esters were fractionated on preparative silver-nitrate-silica gel G TLC plates in chloroform containing 2 per cent ethanol according to Blank *et al.* (1965). The plates were sprayed with dibromo-fluorescein and the linoleic acid identified under a UV-lamp. The methyl linoleate was extracted from the silica gel G with ether and investigated in a Perkin-Elmer 456 infrared spectrophotometer in form of a thin-film.

RESULTS AND DISCUSSION

The results of the investigation are presented in Tables 1-7. For simplicity reasons the results of the GLC of fatty acids have not been tabulated in the usual way. It was felt that the grouping in total saturated acids, oleic acid, linoleic acid and other unsaturated fatty acids will more clearly illustrate the nutritional value of a product.

In the classification of various dietary fats as atherosclerogenic, anti-atherosclerogenic or neutral, we have been relying mainly on the system used by Enselme (1969). He used the ability of various vegetable and animal fats to affect the blood cholesterol level either in human beings or experimental animals, or to create atherosclerotic lesions and related it to the concentration of EFA (linoleic and arachidonic) and the ratio between total saturated and unsaturated acids.

The vegetable oils on the market in Rhodesia consist either of pure groundnut, sunflower and cottonseed oil or blends of these three oils. As we can see from Table 1 the fatty acid composition of the two brands of vegetable oils agrees well with the composition of the groundnut oil. Oils declared as pure sunflower oils agree in fatty acid composition with that of sunflower oil within the limit of natural variations. It should be pointed out that our figures for pure sunflower oil represent only average values. Barker and Hilditch (1950) have found the percentage of linoleic acid in sunflower seed from Rhodesia to be one of the highest in the world.

Table 1

PERCENTAGE FATTY ACID COMPOSITION IN VEGETABLE OILS

Product	Total saturated fatty acids	Oleic acid	Lino-leic acid	Other unsaturated fatty acids
Vegetable oil brand 1	16,6	49,4	35,0	—
Vegetable oil brand 2	16,6	44,9	38,5	—
Sunflower oil brand 1	10,0	31,0	50,0	—
Sunflower oil brand 2	10,6	27,7	61,7	—
Sunflower oil brand 3	11,1	25,0	63,9	—
Pure ground nut oil	17,8	48,0	34,2	—
Pure cotton seed oil	25,9	16,4	57,0	0,7
Pure sunflower oil	12,4	25,4	62,2	—

Although the groundnut oil is generally considered to be without action in relation to atherosclerosis, experimental results are rather controversial (Hammerl *et al.*, 1959; Finzi, 1959; Steiner and Dayton, 1956). As far as the beneficial effect of the sunflower oil is concerned there are not many reports available, but most of them agree on the cholesterol lowering effect of this oil (Pleskov, 1962; Simakov *et al.*, 1966; Zihare, 1969). However, it appears that sunflower oil cannot compete in its anti-atherosclerogenic effect with maize or soya bean oils (Enselme, 1969).

The composition of the modified or hydrogenated plant fats which include margarine and the so-called pure vegetable fats is laid down in Table 2. As it can be seen the content of linoleic acid varies within a wide range (9,5-27,3 per cent)

Table 2

FATTY ACID COMPOSITION OF MODIFIED FATS

EXPRESSED AS PERCENTAGE OF THE ORIGINAL PRODUCT

Product	Total saturated fatty acids	Oleic acid	Lino-leic acid	Other un-saturated fatty acids
Margarine brand 1	17,0	57,5	9,5	—
Margarine brand 2	22,1	39,0	23,3	—
Margarine brand 3	15,5	45,4	23,5	—
Margarine brand 4	20,5	37,8	24,7	—
Margarine brand 5	20,2	36,5	27,3	0,4
Pure vegetable fat brand 1	28,9	50,2	20,9	—
Pure vegetable fat brand 2	32,5	47,0	20,5	—

and this depends on how far the industrial process of the hydrogenation of olefinic double bonds has been conducted. Initially, margarines had a very low content of unsaturated fatty acids and in their atherosclerogenic effect did not differ considerably from butter. Since the evidence on the effect of saturated fatty acids became more numerous manufacturers have been forced to modify margarines by adding natural oils rich in linoleic acid. With such margarines some very satisfactory experiments have been carried out. Boyer *et al.* (1959) demonstrated a reduction of 23 per cent in the blood cholesterol in humans after administering a margarine containing 44,5 per cent of total fats in form of linoleic acid. As it can be seen from Table 2 most of the margarines on the Rhodesian market have a fairly high content of linoleic acid which renders them more suitable than butter. For elderly people and patients suffering from heart complaints preference should still be given to oils with a high linoleic acid content. As far as the "pure vegetable fats" are concerned they differ from margarine in consistency, since they do not contain any water, and in a further reduction in the quantity of linoleic acid.

Table 3

PERCENTAGE FATTY ACID COMPOSITION OF ANIMAL FATS

Product	Total saturated fatty acids	Oleic acid	Lino-leic acid	Other un-saturated fatty acids
Beef dripping	61,5	31,3	1,4	5,8
Pure lard	52,9	34,8	10,3	2,0
Rendered chicken fat	38,2	39,4	18,0	4,4

Table 4

CHOLESTEROL AND FATTY ACID CONTENT OF VARIOUS MEAT PRODUCTS EXPRESSED AS PERCENTAGE OF THE ORIGINAL PRODUCT

Product	Chole-sterol	Total saturated fatty acids	Oleic acid	Lino-leic acid	Other un-saturated fatty acids
Beef sausage	0,23	13,1	11,2	3,7	1,0
Pork sausage 1	0,42	18,6	11,0	4,5	0,7
Pork sausage 2	0,29	11,5	14,3	4,2	1,0
Pork sausage grade 2	0,52	11,0	13,3	4,1	0,6
Vienna sausage	—	8,5	9,5	3,1	0,9
Cocktail sausage	—	19,0	11,7	4,8	0,8
Black pudding	0,37	5,6	6,8	2,1	0,5
Luncheon meat	—	8,2	9,1	3,0	0,4
Premium bacon	0,05	20,3	21,6	4,5	0,2
Ordinary bacon	0,05	24,6	25,2	6,4	0,2

Fairly close in the fatty acid composition to the so-called "pure vegetable fats" are some of the animal fats, notably rendered chicken fat (Table 3). The other animal fats show a very much different fatty acid composition than the vegetable oils or the modified fats. Their main characteristics are a high percentage of saturated fatty acids and a lack of linoleic acid which characterize them as typical atherosclerogenic fats. This also counts for mutton fat which has not been included in this project. It would not be possible to describe all the evidence against the use of the animal fats within the scope of this paper. The interested reader may find a larger number of such references quoted by Enselme (1969).

The fat associated with meat is of a very similar composition and in many cases represents a substantial part of the joint. For instance, beef ribs contain 31 per cent., shoulder of mutton 26

Table 5

FATTY ACID COMPOSITION OF FAT RICH SNACKS EXPRESSED AS PERCENTAGE OF THE ORIGINAL PRODUCT

Product	Total saturated fatty acids	Oleic acid	Lino-leic acid	Other un-saturated fatty acids
Potato crisps brand 1	5,6	12,4	10,2	—
Potato crisps brand 2	5,8	11,8	8,6	0,3
Corn curls	2,8	7,6	6,1	—
Potato puffs	5,8	17,8	11,8	—
Potato chip sticks	6,7	18,8	12,5	—
Peanut butter	9,3	23,2	16,5	—
Dried termites (ex market)	18,1	23,6	4,0	1,2

Table 6

FATTY ACID COMPOSITION OF DAIRY PRODUCTS EXPRESSED AS PERCENTAGE OF THE ORIGINAL PRODUCT

Product	Volatile fatty acids	Higher saturated fatty acids	Oleic acid	Lino-leic acid	Other unsaturated fatty acids
Fresh butter	9,5	44,0	23,7	1,8	3,5
Fresh cream	5,6	25,8	13,9	1,0	2,0
Cheese (Cheddar)	3,8	17,6	9,4	0,7	1,4
Ice cream (in cups)	1,3	5,8	3,5	0,2	0,5

per cent. and loin of pork 23 per cent. Such meat with a high fat content must also be considered as strongly atherosclerogenic. The same counts for various types of sausages whose fat content varies from 15-31 per cent. As it can be seen from Table 4, their linoleic acid content is very low and is derived mainly from the pork fat used in the manufacture of the sausages. Some of them have a rather high cholesterol content which is probably due to the addition of brain, spinal cord or other organs rich in cholesterol.

Very popular in Rhodesia are various types of fat rich snacks mainly produced from potatoes fried in fat. The analysis of such snacks (Table 5) has shown that they have been prepared by frying in ground nut oil, and their content of linoleic acid makes them a rather wholesome addition to the diet. Kaufmann and Mankel (1964) demonstrated that food processing methods like frying or roasting can convert the natural cis-linoleic acid into the trans isomer which has no EFA activity or at least interferes seriously with the EFA activity (Mattson, 1960). Infrared spectrophotometry of the linoleic acid isolated from products listed in Table 5 has shown that the cis-linoleic acid has not undergone any steric changes.

The fatty acid composition of the egg lipids seems to be subject to considerable variations (Enselme, 1969). Our figures (Table 7) for the linoleic acid and cholesterol content are in a very good agreement with the figures given by Fisher and Leveille (1957). The egg is one of the most potent atherosclerogenic food products and the available experimental evidence is numerous (Enselme, 1969). The cholesterol from eggs is absorbed by the intestinal tract at a much higher rate than cholesterol from any other foodstuff. Either the fatty acids or another unknown factor seem to be instrumental in this process (Wells and Bronte-Stewart, 1963; Connor *et al.*, 1961).

Table 7

CHOLESTEROL AND FATTY ACID CONTENT OF FRESH EGGS (EXPRESSED AS GRAMS PER YOLK)

Product	Chole-sterol	Total saturated fatty acids	Oleic acid	Lino-leic acid	Other unsaturated fatty acids
Eggs, medium	0,210	1,48	2,45	0,39	0,20
Eggs, large	0,233	1,91	2,73	0,43	0,23

SUMMARY

Forty-three various dietary fats and fat rich products on the market in Rhodesia were analysed for cholesterol and EFA content. The trend in the consumption is more on the side of the fats with a lower EFA content.

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