Influence of palm oil and palm oil fractions on protein utilisation

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The influence of dietary palm-oil fractions on protein utilisation has been investigated in the growing rat. At 30 days of age, 4-6 groups of four animals were offered one of six semi-purified diets that differed only in the palm-oil fraction. Diets contained 200g casein, 550 g carbohydrate, and 200g fat/kg. The different palm-oil fractions were: crude palm oil (CPO), refined palm-kernel oil (PKO), refined palm olein (RPO), refined palm stearin (RPS), refined palm oil (RPOL). The control groups were given Olive oil (OO) as the dietary fat source. The conversion efficiency of dietary protein was assessed as Net Protein Utilisation (NPU), using a 10-day comparative carcass technique.

Weight gain and food intake were not altered by the various palm-oil fractions. However, the NPU of rats given RPO was significantly higher ($p<0.05$) than that of rats given all other palm-oil fractions or the OO control. It is concluded that the RPO has the potential to significantly improve NPU in the rat, compared to four other palm-oil fractions as well as olive oil.

Introduction

For more than a century, nutritionists have been concerned with the factors that affect protein utilisation. For example Willcock and Hopkins[1], showed that amino acid composition was a crucial factor influencing protein utilisation. The importance of energy intake in altering the efficiency of protein utilisation was first demonstrated by Rubner[2] in 1879. It is now generally accepted that nitrogen balance is impaired when energy intake is inadequate[3,4].

The question of whether the type rather than the amount of non-protein energy is of any importance in affecting the utilisation of protein is less well resolved. Munro[5], synthesised all these observations in a comprehensive review entitled 'Carbohydrate and Fat Factors in Protein Utilisation and Metabolism'. He concluded: "Thus nitrogen balance undergoes temporary impairment when fat is substituted isocalorically for dietary carbohydrate. Carbohydrates also play a special part in conserving protein of endogenous as well as of dietary origin, for the feeding of carbohydrate to fasting animal reduces nitrogen output but the feeding of fat does not have this effect until the fat stores are exhausted".

With the question of the superiority of carbohydrate or fat as an energy source for protein metabolism unresolved, another matter of interest was the impact of the type or nature of fat in particular on protein metabolism. Deuel and co-workers[6] reported no difference in growth in rats fed butter-, maize-, cotton seed-, olive-, groundnut-, or soy oil. Whereas Thomasson[7], who investigated 20 different oils, concluded that there was a difference in growth of rats fed various oils and noted that some oils in particular (rapeseed, kapokseed) produced extremely poor growth. similarly Naismith and Qureshi[8] reported poor growth in animals fed mustard oil. Such reports, however, are difficult to interpret in terms of protein metabolism. While poor growth (weight gain) almost always indicates a reduced nitrogen balance, the poor weight gain can also result from changes in food intake, with the efficiency of nitrogen utilisation being unimpaired. Another cause for poor growth may be an increased energy expenditure, or a fall in food intake such that although the efficiency of nitrogen utilisation is reduced it is a secondary effect to energy restriction[9-11].

Despite the conflicting reports and possible influence of fat on growth, the general consensus among researchers has been to accept that the chief function of fat is as an energy source and thereby only influence the protein:energy ratio of the diet. However, a preliminary study by our group has indicated that the efficiency of protein utilisation (NPU) may indeed be influenced by the fat source. Palm oil was observed to give a higher NPU value than butter-, sunflower-, soy-, or olive oils[12]. The purpose of this study is thus, to investigate the influence of dietary fat on protein utilisation, with specific reference to palm oil.

Materials and methods

Animals and diets

Weanling male (21-23 days old) Sprague-Dawley rats (OLAC Ltd, Shaws Farm, Blackthorn, Oxon, UK) were kept in a room maintained between 26-28°C with a 12 hour light and dark cycle. All animals were allowed free access to food and water.

Rats were fed the BP (Witham, Essex, UK) stock diet for 7 days prior to the NPU assay. At 30 days of age they were divided into groups of 4 and offered one of 6 semi-purified diets that differed only in the palm oil fraction. The composition of the diet is given in Table 1 (Diet P+). The fat source of each of the semi-purified diets was as follows: crude palm oil (CPO), refined palm kernel (RKO), refined palm olein (RPO), refined palm stearin (RPS), and refined palm oil (RPOL). A 7th control group was offered an identical diet but with olive oil (OO, control) as the source of fat. Two further dietary groups were fed on free-protein diets (Diet P^-, Table 1), with either refined olein (P^-RPO) or crude palm oil (P^-CPO) as the fat source.

The metabolisable energy content of the diets were calculated to be 20.15 kJ/g (on an air-dried basis), by applying the conversion factors of 17.0, 37.0 and 17.0 kJ/g respectively for the energy content of protein, fat and carbohydrate.

Groups of rats matched for body weight were killed at start of the experimental period, to provide an initial value of total body nitrogen content. During the next 10 days (the duration of NPU assay), each group was housed in a cage with wire mesh at the bottom. The spilt food was collected on a plastic tray covered with filter paper and kept underneath the cage. The powdered diet was dispensed in glass food pots. Energy and protein (nitrogen)

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intakes were calculated from the amount of air-dried food consumed multiplied by the nitrogen content of the diets, to give the nitrogen intakes (I) of the animals. On the 10th day of the assay period, the animals were killed by cervical dislocation. The water content of the carcasses (including gut contents) was determined by drying to a constant weight.

Table 1. *Composition of semi-purified diets*

Ingredient	Diet P$^+$ (g/kg)	kJ/kg	Energy (%)	Diet P$^-$ (g/kg)
Palm oil fraction*/ olive oil	200	7400.0	36.7	200
Casein	200	3400	16.9	-
Sucrose/Corn-meal	550 (8:3)	9350	46.4	750
Vitamin and mineral mix†	50	-	-	50

P, protein; +, adequate; -, deficient; † Palm oil fractions purchased from Anglia Oils Ltd, King George Dock, Hull, UK.
*Mineral and vitamin mix obtained from SDS, Witham, Essex. UK.

Analytical methods

Nitrogen content of carcass and food. The dried carcasses from each group were pooled and macerated. Samples of the finely minced carcass and of dried food were analysed for nitrogen using the Kjeldahl method[13].

Efficiency of protein utilisation. This was calculated using the formula for Net Protein Utilisation (NPU) described by Miller and Bender[14]. NPU= $(B-B_k)/I$

Where B = body nitrogen of test diet fed group
B_k = body nitrogen of non-protein fed group
I = nitrogen intake of test group

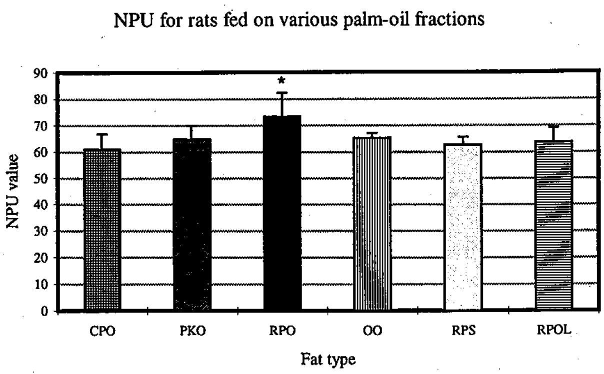
Statistical analysis

Differences between the dietary groups were analysed using one-way analysis of variance (ANOVA). Results are expressed as the mean and its standard deviation.

Results

Growth rate of animals fed on protein-containing diets was not significantly altered by the source of dietary palm-oil fraction nor by palm oil compared to olive oil (Figure 1). The food intake of rats was similar on all the protein-containing diets, as was the amount of nitrogen retention (Table 2). However, the NPU of rats fed the diet containing refined palm olein was significantly higher (P<0.05) than all the other palm oil fractions and the olive oil control (Figure 2).

Figure 2. NPU for rats fed on various palm-oil fractions and olive oil. Values are the means with SD (*n* 4-6 trials each). Significantly different, ANOVA: *$P<0.05$.



Discussion

The dietary palm oil fraction did not influence the amount of feed consumed by experimental animals. Thus, feed palatability was not a factor influencing protein retention.

The rate of weight gain was also similar is all the groups tested. A similarity in the growth rate of rats fed on diets containing either CPO or RPO was also noted by Manorama and Rukmini[15].

The NPU in the RPO-fed groups was enhanced on average by about 15.3% compared to animals fed on any of the other 4 palm-oil fractions. It is well known that the relative proportions of saturated to unsaturated fatty acids (u/s) are the main determinants of an oil's physical and biological properties[16]. As compared to the other 4 palm-oil fractions, palm olein has the highest u/s ratio (1.23 compared to 1.00, 0.57, 0.23, for RPOL, RPS, and PKO respectively[17]). The digestible energy in growing pigs has been shown to improve exponentially as a function of u/s[18]. Digestibility of oils can exert an influence on NPU[7]. Although, nitrogen retention did show a slight improvement in RPO-fed groups, the increase was not statistically significant.

More recently Abe *et al*[19], reported that different palm-oil saturated fatty acids can exert differential effects on various lipid parameters in the rat. Whether the same can be said for protein metabolism is still to be investigated.

Manorama and Rukmini[15] measured NPU in weanling Wistar rats fed on 10% of either CPO or RPO for 28 days. They could not find any significant difference in NPU between the two oils. Furthermore, the mean NPU values they reported for the CPO-

Figure 1. Growth curve of rats fed on diets containing various palm oil extracts: CPO (+), RPK (□), RPO (6), RPS (▲), RPOL (Δ), P^- RPO (●) P^-CPO (O) and OO (◊) as control, For details of dietary treatment, see Table 1. Points are means of 4-6 trials.

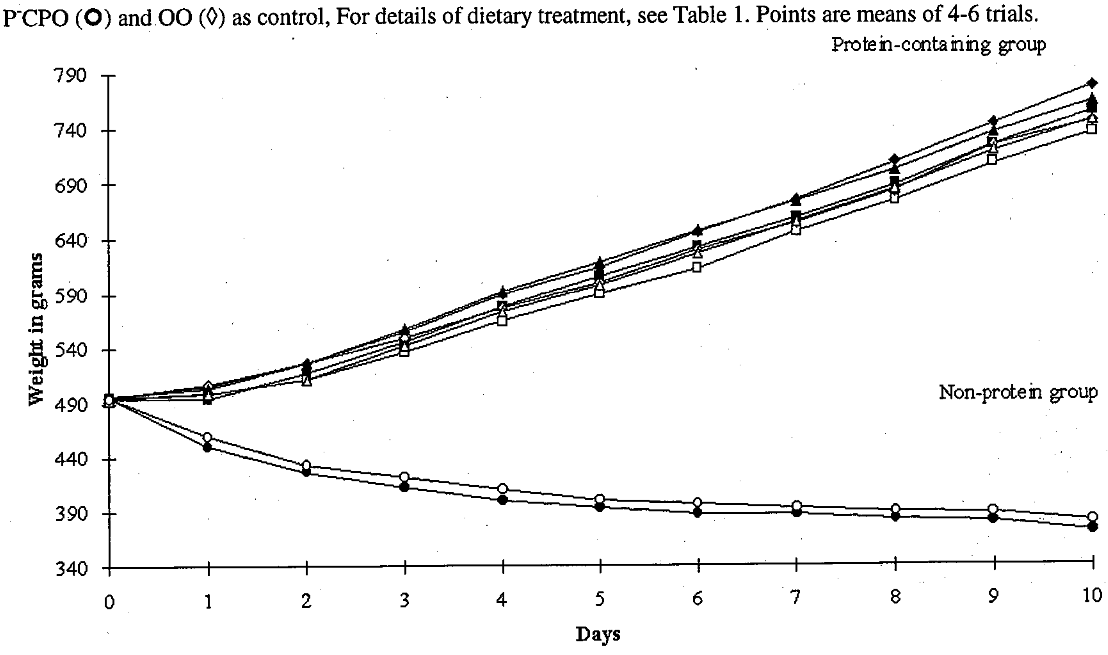


Table 2. *Weight gain, energy intake and Nitrogen balance in rats fed various palm oil fractions.*
(Mean values and standard deviations for 4-6 groups, each of 4 rats, over a 10 d assay period)

Dietary treatment	Weight gain (g)		Energy intake (MJ)		Nitrogen intake (g)		Nitrogen retained $B-B_k$ (g)	
	mean	SD	mean	SD	mean	SD	mean	SD
CPO	258	29.2	11.1	1.52	17.8	2.42	10.0	1.36
PKO	236	19.9	10.5	1.19	16.7	1.90	9.7	1.41
RPO	260	44.1	10.6	1.31	16.9	2.09	11.4	3.11
RPS	244	55.4	10.6	1.81	16.9	2.88	10.0	2.55
RPOL	240	27.0	10.2	1.36	16.3	2.16	9.9	1.38
OO (control)	255	34.1	10.6	1.88	17.0	3.00	10.6	1.91

Average starting weight approximately 107.5g/rat

and RPO-fed groups were respectively, 13% higher and 8% lower than the present results. A direct comparison of those results with the present ones is not justified since both the design and duration of the two studies were different.

The practical implication of our studies may be summarised as follows:

Millions of children around the world suffer from protein-energy malnutrition of which commonest forms are kwashiorkor, marasmus or marasmic-kwashiorkor. These are characterised by muscle wasting, loss of adipose tissue and oedema. The routinely administered rehabilitation formulae for catch-up growth in malnourished children is based on the following composition: skimmed milk powder 110g, sugar 50 g, oil (usually groundnut) 60 g contained in 1L water. This liquid diet provides 1180 kcal/L and 38.5 g protein/L.

On such a diet malnourished children tend to recover their initial body weight within 5-6 weeks. Our results indicate that the use of RPO enhances N balance and thus in theory, should improve tissue accretion. A human trial, with RPO as the fat source during nutritional rehabilitation of malnourished children, may be a practical outcome of these studies.

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棕櫚油 和棕櫚油制劑對蛋白質利用的影響

摘要

作者用年齡30 日的大鼠爲對象，研究膳食中不同棕櫚油制劑對蛋白質利用的影響，4只大鼠爲一組，分成6組，每組給予僅棕櫚油制劑不同的半純化膳食，基本膳食每公斤含200克酪蛋白，550克碳水化合物和200克脂肪. 不同的棕櫚油制劑是：粗棕櫚油（CPO〕，精制棕櫚仁油（PKO〕，精制棕櫚油酸甘油酯（RPO〕，精制棕櫚硬脂酸甘油酯（RPS〕，精制棕櫚油（RPOL〕. 對照組給予橄欖油（OO〕作爲膳食來源，膳食蛋白質利用效價用淨蛋白質利用率（NPU〕來恒定，用10日尸體比較技術. 體重和食物攝取不因不同的棕櫚油制劑而改變，但是，給予RPO大鼠的NPU較其它組，包括對照組爲高（P<0.05〕. 作者得出結論，與其它四組棕櫚油制劑和對照組比較，RPO能明顯改善大鼠的NPU.

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