A C T A A L I M E N T A R I A P O L O N I C A
Vol. IV (XXVIII), No. 3 1978

ANNA GRONOWSKA-SENGER
KATARZYNA KUBICKA
ANDRZEJ DĄBROWSKI

EFFECT OF FOOD FATS QUALITY ON UTILIZATION OF VITAMIN A AND PROWITAMIN A BY ORGANISMS

Institute of Human Nutrition
Warsaw Agricultural University

Key words: vitamin A, β-carotene, peroxide, lard, rats, liver.

Two experiments were carried out on Wistar rats (both sexes). The rats were fed 30 μg(day) rat of ß-carotene in oil solution, or 30 I.U. (day)rat of retinyl palmitate, and semisynthetic, vitamin A — free, diet containing 15% lard. Increase of peroxides content in lard induced a reduction in carotene utilization, as evidenced by vitamin A content in the liver.

Fat quality has a very significant effect on utilization of vitamin and provitamin. When being processed in food, fats accumulate toxic compounds (peroxides, hydroperoxides, carbonyl compounds, polymers, and others). They lower nutritional values of the fat and have negative effects on utilization of vit. A and provit. A by laboratory animals [5, 15, 19, 20]. The same reactions develop in storaged fat, although at a slower rate [7]. Consumption of spoiled fats leads to morphological changes in liver, kidneys, cardiac muscle, and sexual organs. It also negatively affects the process of growth [18, 20]. The changes that come first are in the liver, which is the organ storing vitamin A, hence bad quality fat may significantly influence the general utilization of the vitamin by the organism. The increasing proportions of technologically processed, heated and unheated, fats in human nutrition calls for analyses of their effects on utilization of other food components. The present study follows from this need of research.

MATERIALS AND METHODS

Commercially available pork lard was placed in a 5 cm thick layer in a vessel (14.5 cm in dia) and heated. The heating was carried on in a laboratory drier at 105°C until every batch reached previously assumed contents of peroxides (Lea number 1, 5, 10, 20 and 40).

The processed lard was added to the experimental diets in 15%. Two 10-days long biological experiments were carried out on Wistar rats of both sexes (ratio 1:1), averaging ca 50 g body weight and standardized as to the vit. A content in livers. The animals were fed ca 30 μg/day/rat of oil solutions of β-carotene, or 30 I.U./day/rat of retinyl palmitate. Preparation of the solutions and the manner of feeding followed earlier experiments [4, 10]. The animals were kept in individual cages, which were put in groups of six. They received water ad libitum and an experimental diet free of vit. A [12]. The rate of consumption was controlled. The system of experimentation and the applied symbols are given in Table 1. The degree of utilization of β-carotene and vit. A utilization by the rat's organism was determined with the liver test [3]. After the experimental period the rats were anaesthetized with ethyl ether. A heparin-treated syringe was used to take heart blood; livers were removed. The levels of vit. A in blood and in liver were determined [12, 13]; the carotene level in feaces [2] and the lard's peroxide value were defined as well [9]. Samples of blood and liver were stored at-4°C for about a week to be used in subsequent analyses.

Table 1. Experimental design

Group	Lea number (lard)	Carotene μg(day)rat	Vitamin A I.U.(day)rat
	Experiment 1		
O+S	0.60	—	—
K+S	0.60	30	—
K+S_1	1.13	30	—
K+S_5	5.90	30	—
K+S_{10}	11.80	30	—
K+S_{20}	21.30	30	—
K+S_{40}	43.35	30	—
	Experiment 2		
O+S	0.60	—	—
A+S	0.60	—	30
A+S_1	1.50	—	30
A+S_5	4.94	—	30
A+S_{10}	11.55	—	30
A+S_{20}	22.80	—	30
A+S_{40}	42.70	—	30

RESULTS AND DISCUSSION

EXPERIMENT 1

Average increments of body weight in the animals (Table 2) and the growth diet efficiency (i.e. increase of body weight per 1 g consumed diet) were about the same for all the groups. A different quality lard did not show effects on the growth rate of the rats. It was due to a short period of experimentation which could not provide so quickly any negative results of feeding a poor quality fat. As it is reported in literature [6, 11, 14, 17], the effect of reducing the growth rate was only arrived at during long-term experiments. It was account for by lower digestibility of fats and the lowering of the level of energy available in such fats.

Table 2. Mean increase of body weight and mean intake of feed in relation to fat quality

Group	Total increase of body weight (g)	Total diet consumption (g)	Diet growth efficiency
	Experiment 1		
O+S	35.1	85.8	0.41
K+S	36.1	83.9	0.43
$K+S_1$	39.9	90.0	0.44
$K+S_5$	36.4	90.3	0.40
$K+S_{10}$	39.3	94.8	0.41
$K+S_{20}$	38.9	92.9	0.42
$K+S_{40}$	44.6	110.1	0.40
	Experiment 2		
O+S	36.3	82.7	0.44
A+S	36.6	83.5	0.44
$A+S_1$	35.8	84.0	0.43
$A+S_5$	37.6	90.2	0.42
$A+S_{10}$	36.9	89.5	0.41
$A+S_{20}$	35.6	85.4	0.42
$A+S_{40}$	39.6	92.4	0.43

The quality of lard did influence the utilization of β-carotene as vit. A (Table 3). Most of the vitamin was stored by the rats fed with fresh lard (K+S), and least was observed those receiving the worst quality lard ($K+S_{40}$). The obtained reduction in ratio of the group fed with fresh lard was 47%. The highest rate of decrease, by about 17%, was observed between the control group (K+S) and the group fed with the Lea 1 ($K+S_1$) lard, and then between groups fed with lards Lea 10 ($K+S_{10}$) and 20 ($K+S_{20}$) — ca 15%, and it was ca 10% between the groups receiving lards Lea 5 (K+S) and 10 ($K+S_{10}$). In the other two intervals the drop fluctuated within 3%.

Table 3. Mean liver and plasma vitamin A content in rats fed the lard of various quality and carotene

Group	Carotene μg/rat		Liver weight (g)	Vitamin A(I.U.)		
	consumed (U)	excreted		in liver	in 1g of liver	in 100 ml of plasma
O+S	—	—	5.09	55.6	11.2	87.0
K+S	292.5	63.1	4.86	388.0	82.3	300.0
$K+S_1$	292.5	51.4	5.41	321.6	60.4	251.0
$K+S_5$	292.5	47.5	5.10	312.5	64.3	222.0
$K+S_{10}$	292.5	40.6	5.16	275.3	54.9	188.0
$K+S_{20}$	292.5	31.6	4.78	216.8	47.4	131.0
$K+S_{40}$	292.5	19.6	5.06	204.9	41.0	125.0

These relations were reflected in the level of vit. A in blood plasma (Table 3). As in the case of vit. A in liver, an increase in the content of peroxides led to a lowering of vit. A in plasma. The reduction was quite rapid in groups fed with lard of the peroxide value from 1 to 20. Further increase in peroxides did have a nagative effect on the process but the rate of changes was much slower.

The above dependencies influences the percentage of utilization of β-carotene, both as regards quantities consumed (U) and quantities absorbed (Table 3 and Fig. 1).

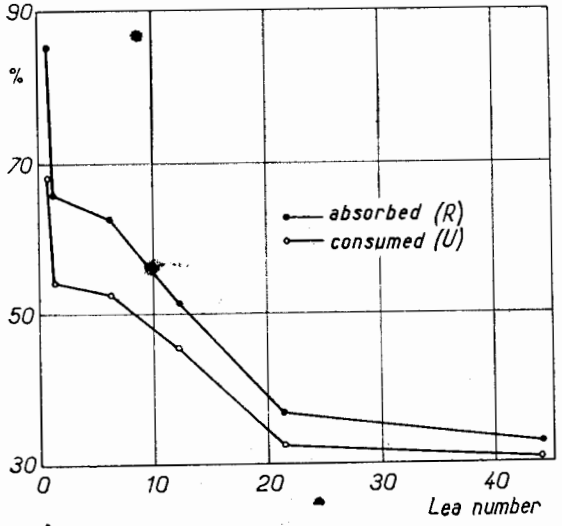

Fig. 1. Utilization of ß-carotene as a function of carotene consumed and absorbed in relation to various quality of lard

In the case of lard with Lea 0.6 to 1 the utilization of consumed carotene (U) per unit of the Lea number dropped by 27.4%. Much slower reduction in carotene utilization, by 19.5% (1.3% per unit of growing

Lea number) appeared also in animals receiving Lea 5 to 20 lard. Within intervals Lea 1 to 5 and 20 to 40 the U changes were insignificant.

Utilization of β-carotene as percentage of the absorbed (R) quantity was higher than the consumed (U) value, and similary to the latter, it varied in all intervals.

In follows from the data that quality of food fats largely affects the metabolism of β-carotene in a rat's organism. Even small changes of the quality caused considerable reduction in the carotene utilization rate, probably on account of decomposition of the provitamin by peroxides present in the fat put in diets. The losses grew with growing content of peroxides but only to a limit — Lea 20. Above that value peroxides in the lard had a much less dramatic effect on carotene utilization. The above more or less pertains to human organism, undoubtedly, although the literature is concerned rather with determination of the degree of utilization of the provitamin and its absorption from different vegetables. No data are available on the links with fat quality.

EXPERIMENT 2

According to the expectations, fat quality did not affect the rate of body weight (Table 2). This was caused by the factors discussed in Experiment 1. The actual average consumption of fats was lower from the theoretical one due to lower (8-9 g) than the assumed (10 g) consumption of food. This remark also pertains to Experiment 1. Utilization of vitamin A by a rat's organism depended on quality of the fat in food (Table 4).

Growing number of peroxides lowered the degree of vitamin A stored in liver — about 37% less in the group fed lard Lea 40, as compared to the fresh lard group (A+S). Similar dependencies appeared as regards the content of vit. A per 1 g liver. The relatively highest drop in the storaged vit. A, 23% and 31%, respectively, was observed in groups fed lards Lea 20 and Lea 40. The differences between the other groups were rather minor. Also the level of vitamin A in blood plasma underwent similar changes. This was reflected in the percentage of recovered vit. A Fig. 2).

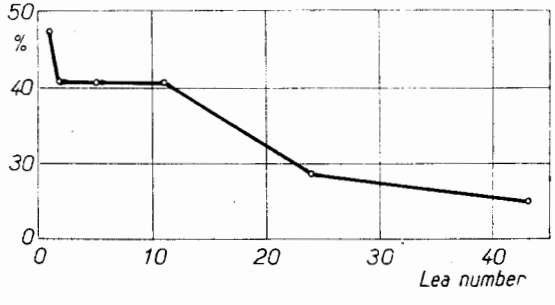

Fig. 2. Recovery of vitamin A in the liver of rats fed retinyl palmitate and lard of various quality

Table 4. Mean liver and plasma vitamin A content in rats fed the lard of various quality and retinyl palmitate

Group	Vitamin A consumed I.U./rat	Liver weight (g)	Vitamin A (I.U.)		
			in liver	in 1g of liver	in 100 ml of plasma
O+S	—	5.1	19.5	3.8	153.0
A+S	296.0	4.8	150.2	31.3	155.0
$A+S_1$	296.0	4.9	141.9	29.0	155.1
$A+S_5$	296.0	4.8	140.8	29.3	145.0
$A+S_{10}$	296.0	5.0	141.3	28.3	135.0
$A+S_{20}$	296.0	4.8	104.9	21.9	127.5
$A+S_{40}$	296.0	4.9	95.6	19.5	120.6

The rats fed with the poorest quality lard showed 22% lower utilization of vitamin A as compared with the group receiving fresh lard. The utilization was dependend on the content of peroxides in a given lard. This was particularly conspicuous at higher levels of these compounds in fat — from 10 to 40. The presence of peroxides probably increased oxidation, and as a result, there were losses in utilization of vit. A. According to some authors [1, 8], the lower level of vit. A in liver, when different quantities of fat were, fed, was produced not only by peroxides but also by increased excretion due to absorption disturbances.

The obtained data indicate that fat quality largely affects metabolism as well as utilization of vit. A and provit. A by a rat's organism. The above observations are more or less pertinent to human organism as well. For this reason that the proportion of processed fats in our food grows steadily it would be advisable to continue not only biological research on nutritional value od edible fats but also on absorption and utilization of vit. A and its provitamins by human body. Introducing new technology and storage optimum conditions could be created for utilization of the component by our organisms.

CONCLUSIONS

1. The changing of the lard quality did no significantly affect the body weight increase in the rats.
2. The poorer quality of lard reduced the utilization of β-carotene and vit. A by the rat, as evidenced by lower amounts of vit. A present in liver and plasma.
3. On acoount of the growing share of human nutrition being taken by processed fats it would be recommendable to continue research in this direction, particularly involving human organism, in order to provide optimum conditions for utilization of vitamin A and its provitamins.

LITERATURE

1. Ames S. R.: Am. J. Clin. Nutr., 1969, **22**, 934.
2. Berger S.: Roczn. PZH 1963, **4**, 473.
3. Berger S., Gronowska-Senger A.: Acta Vitamin. Enzymol., 1974, **28**, 103.
4. Berger S., Gronowska-Senger A., Chabrowska B.: Roczn. Chemii i Techn. Żywn., 1966, **12**, 157.
5. Bronisz H., Abratowska M., Leszczyńska H., Olędzka R., Staniszewska L.: Roczn. PZH 1958, **9**, 255.
6. Brzozowska E.: Wpływ technologicznego ogrzewania tłuszczów na niektóre ich cechy fizykochemiczne oraz wybrane wskaźniki biologiczne w organizmie szczurów doświadczalnych. PHDthesis. SGGW-AR, Warszawa 1971.
7. Budzyńska-Topolowa J.: Gosp. Domowe 1974, **1**, 14.
8. Cawthorne M. A., Bunyan J., Diplock A. T., Mureell E. A., Green J.: Br. J. Nutr., 1968, **22**, 133.
9. Chabrowski K., Zalewski S.: Przewodnik do ćwiczeń z wybranych działów towaroznawstwa gastronomicznego. SGGW-AR, Warszawa 1970.
10. Gronowska-Senger A., Gryziak H., Bartnik J.: Acta Physiol. Polon., 1972, **2**, 307.
11. Kaunitz H., Johnson R. E., Pegus L.: J. Am. Oil. Chem. Soc., 1965, **42**, 9.
12. Korycka M., Daniewski M., Berger S.: Zeszyty Nauk. SGGW TRS 1968, **5**, 89.
13. Manual for nutrition surveys. ICNND. Washington US Goverment Printing Office 1963.
14. Nolen G. A., Alexander J. C., Artman N. R.: J. Nutr., 1967, **93**, 337.
15. Opuszyńska T.: Roczn. PZH 1973, **1**, 39.
16. Opuszyńska T.: Roczn. PZH 1973, **4**, 425.
17. Raju N. V., Narayana R. M., Rajagopalan H.: J. Am. Oil. Chem. 1965, **42**, 9.
18. Zalewski S., Brzozowska E., Oleśkiewicz Z., Bartnik J.: Roczn. Techn. Chemii Żywn., 1972, **2**, 255.
19. Ziemlański S., Opuszyńska T., Kruś S.: Roczn. PZH 1972 **6**, 685.
20. Ziombski H., Łuszcz A.: Roczn. PZH 1976, **3**, 317.

Manuscript received: October, 1977.
Authors address: 02-975 Warszawa, Nowoursynowska 166.

A. Gronowska-Senger, K. Kubicka, A. Dąbrowski

WPŁYW JAKOŚCI TŁUSZCZU W DIECIE NA WYKORZYSTANIE WITAMINY A I JEJ PROWITAMINY PRZEZ ORGANIZM

Instytut Żywienia Człowieka SGGW-AR, Warszawa

Streszczenie

Badano wpływ jakości smalcu w diecie na wykorzystanie karotenu i witaminy A przez organizm szczura. Wykonano dwa 10-dniowe doświadczenia na białych szczurach rasy Wistar obu płci, którym podawano per os roztwory olejowe ß-karotenu w ilości 30 mcg/dzień/zwierzę lub palmitynianu retinolu — 30 j.m./dzień/zwierzę oraz dietę semisyntetyczną pozbawioną witaminy A, zawierającą 15% smalcu. Wykorzystanie witaminy A oraz karotenu jako procentu wchłoniętego i spożytego określono testem wątrobowym. Oznaczono również poziom witaminy A w osoczu krwi. Wykazano spadak wykorzystania witaminy A oraz jej prowitaminy w miarę pogarszania się jakości smalcu.