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NUTRITIONAL VALUE OF PROTEIN AND OIL IN RUBBER SEED (*Hevea brasilensis*)[1]

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Resumen

La producción de hule de Hevea brasilensis *está aumentando en Centroamérica. Esto significa una mayor disponibilidad de semilla, que por el momento se usa en cantidades limitadas. Este trabajo presenta información química y biológica sobre el potencial nutritivo de la semilla en alimentación animal. La semilla cruda y seca contiene 17.6% de proteína y 36.7% de aceite crudo. El contenido de todos los aminoácidos esenciales en la proteína es adecuado excepto en el caso de la lisina, dato confirmado en ensayos con animales de laboratorio. El proceso de cocción por extrusión se tradujo en un mejoramiento de la calidad de la proteína y es una forma efectiva de eliminar el HCN de la semilla. El aceite tiene un contenido alto de ácidos grasos C18:2 con una digestibilidad de 84% crudo, que aumenta a 93% cuando se calienta. Sin embargo, los valores son inferiores a los de la digestibilidad del aceite de algodón. Los resultados del estudio indican que la semilla del árbol de hule tiene potencial en nutrición animal y en la industria del aceite.*

Introduction

In recent years there has been an interest to find uses for the seed of the rubber tree (*Hevea brasilensis*), whose production is increasing in Central America. According to local statistics, 10 342 ha of land were planted with 4 292 621 trees in 1972 in Guatemala (5, 17). On the basis of about 5 kg of seed per tree, the potential availability of seed is in the neighborhood of 21 463 metric tons.

The kernel itself, that is, once the hull has been removed, contains 31.7 per cent moisture, 3.7 per cent crude fiber, 29.6 per cent fat and 11.4 per cent protein (3, 4, 6, 18). Giok *et al.* (11) reported on the chemical composition of the kernel, the amino acid content of the protein and its nutritional quality. They indicated the kernel to contain 32.3 per cent fat and 27.0 per cent protein. Amino acid analysis showed the protein to be a good source of lysine and tryptophan, but low in sulfur-containing amino acids. Its protein quality as assayed by the PER (PER = Protein efficiency ratio: weight gain/protein intake) method was 2.0. Fetuga *et al.* (9) conducted a more complete chemical and biological study on the nut of the rubber tree, reporting on chemical composition, amino acid content for rubber seed protein as compared to soybeans and peanut, and their results showed the full-fat seed meal to be nutritionally superior to the defatted sample. The nutritional assays suggested lysine and sulfur amino acids to be limiting the quality of the protein. Other authors (7, 15) have fed the rubber seed meal to rats and chicks, reporting fair quality values. One of the problems with this vegetable source is that it contains HCN, which can be removed by a thermic treatment.

The need for oil and protein in Central America is increasing; therefore, it was of interest to study the chemical and nutritional nature of these two substances as found in the seed.

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Materials and methods

The rubber tree belongs to the *Euphorbiaceae* and there are two species, both from Brazil, utilized for latex production. One of them is from Ceará (*Manihot glaziovii*) and the other one from Pará (*Hevea brasilensis*). Both are now grown in various regions of the world. *Hevea* seed obtained from plantations in the tropical lowlands of Guatemala was used for the study.

The seeds were first decorticated by mechanical means to separate the hulls from the kernel. The kernels were then ground to 20 mesh and used for oil extraction. This was accomplished by either a hydraulic pressing operation or by hexane extraction on previously air-dried samples. The crude oil resulting from either process was purified by filtration through celite and stored at 4°C until utilized. The solvent extracted meal was desolventized by applying moderate temperatures an air, in a laboratory convection oven. This material was also stored at 4°C until used.

For other nutritional studies, the dried nuts were obtained from seeds passed through a hammer mill without screens. The resulting product was then separated into hulls and meats. The meats were then cooked in a Brady extruder at a temperature of 315°F. For the feeding trials, the extruded product was fed full-fat or hexane extracted.

The oil produced either by hydraulic pressing or solvent extraction was analyzed for free fatty acids, saponification index and iodine number by the AOCS official methods (1). The oil was also subjected to nutritional evaluations through feeding experiments with rats fed 10 per cent casein diets with varying amounts of oil.

The original kernel as well as the oil-extracted meal were analyzed for their chemical composition following AOAC official methods of analysis (2). The oil-extracted meal was analyzed for calcium, phosphorus, iron and HCN by the methods of the AOAC (2), Fiske and Subbarow (10) with modifications by Lowry and López (13), by Jackson (12) and Moss and Mellon (14), and by Easley *et al.* (8), respectively. The meal was also assayed for its essential amino acid content by microbiological techniques on acid hydrolyzate for all amino acids and on an alkaline hydrolizate for tryptophan (19).

Protein quality of the meal was measured by the protein efficiency ratio at approximately 10 per cent protein level in the diet. The quality of the protein was also evaluated by supplementing a 10 percent protein diet of rubber seed protein with the amino acids lysine and methionine. In the protein quality assays, the rubber seed meal was incorporated into a basal diet made with a mineral mix, cod liver oil, refined cotton-seed oil when necessary and a complete vitamin B mixture. Cornstarch was used to adjust to 100 per cent. For the studies on the digestibility of the oil, a basal diet was used made of casein 12 per cent, mineral mixture 4 per cent, cod liver oil 1 per cent, amounts of rubber seed oil varying from 5 to 20 per cent and starch to make up to 100 per cent. Either 5 per cent refined cottonseed or soybean oil was used as reference oil. All diets were supplemented with a complete vitamin B mixture. After an adjustment period of 7 days, all fecal output was collected for a 5-day period. The dried feces were analyzed for oil after grinding.

Results

Chemical composition

Table 1 summarizes the results on gross chemical composition of the kernel of the seed, the solvent-extracted seed and extruded seed. With respect to the decorticated seed, attention should be given to the high moisture level and the relatively high amount of ether extract. The HCN content is also high. The solvent extracted meal shows an expected high protein content and a significant low level of HCN. Of interest is the relatively high level of Ca. The extruded product has 20.2 per cent protein and 45.6 per cent fat.

Data on essential amino acid content of rubber seed protein are shown in Table 2, together with that of other oilseed sources (16) for purposes of comparison. Based on experimental evidence on the other oilseed meals, the amino acid pattern of the protein of the rubber seed is deficient in lysine, sulfur amino acids and tryptophan. The most significant deficiency appears to be in sulfur amino acid content.

Protein quality of rubber seed

Two experiments were performed. The results are shown in Tables 3 and 4. In the first experiment, using hexane-extracted kernels, PER was increased by lysine addition; however, methionine addition alone or in the presence of lysine did not improve protein quality above the unsupplemented diet or the one which was supplemented with lysine. The second study carried out, in which raw, cooked and extruded samples were tested, showed the same tendencies to amino acid addition; however, the unsupplemented rubber seed diet gave a significantly lower PER value than that observed in the first study. Further cooking

Table 1. Chemical composition of rubber seed (%).

	Decorticated rubber seed	Raw	Rubber seed meal[a]	Extruded
Moisture	45.2	5.4	13.4	2.6
Protein (N x 6.25)	8.9	17.6	29.1	20.2
Ether extract	22.2	36.7	9.8	45.6
Crude fiber	3.1	–	6.4	–
Ash	2.0	3.1	4.8	3.3
Carbohydrate (by difference)	18.6	–	36.5	–
Calcium, mg %	–	–	475	–
Phosphorus, mg %	–	–	34	–
Iron, mg %			132	.
HCN, mg %	121	–	0.75	–

[a] By hexane extraction of oil.

Table 2. Essential amino acid content of rubber seed protein (mg/gN).

	Rubber seed	Soybean[a]	Cottonseed[a]	Peanut[a]	Sesame[a]
Arginine	321	452	702	669	547
Histidine	110	149	166	152	121
Isoleucine	159	336	236	257	261
Leucine	170	482	369	380	461
Lysine	240	395	268	223	160
Methionine	104	195	188	149	311
Phenylalanine	224	508	498	540	461
Threonine	151	246	221	168	194
Tryptophan	41	86	74	69	91
Valine	246	328	308	311	244

[a] Orr and Watt (16).

Table 3. Protein quality of rubber seed meal and effect on amino acid supplementation in young growing rats.

Diet	Average weight gain, g[a]	PER[b]
Rubber seed meal (RSM)	30 ± 1.9	1.25 ± 0.05
RSM + 0.20% L-lysine	47 ± 6.6	1.71 ± 0.14
RSM + 0.20% methionine	27 ± 1.3	1.13 ± 0.05
RSM + 0.20% L-lysine	–	–
RSM + 0.20% methionine	45 ± 4.4	1.63 ± 0.07

a Protein in diet: 10.9%. Average initial weight: 42 g.

b Protein efficiency ratio: Weight gain/protein intake.

of the cake did not improve protein quality, although a slightly higher value was found for the extruded product.

Some physicochemical characteristics of the oil

Table 5 summarizes the results on some characteristics of the oil obtained by pressing and by hexane extraction. They were essentially the same, although free fatty acid content in the solvent extracted oil was slightly higher than that obtained by pressing. The free fatty acid composition is shown in Figure 1.

Nutritive value of the oil

The nutritional value of the oil was determined by rat growth performance. In one experiment, the

Table 4. Protein quality of raw, cooked and extruded rubber seed and effect of amino acid supplementation as determined in young growing rats.

Diet	Average weight gain g[a]	PER
Raw rubber seed	13	0.66
Cooked rubber seed	11	0.62
Extruded rubber seed	16	0.80
Extruded rubber seed + lysine + tryptophan	41	1.60
Extruded rubber seed + oil extracted	18	0.75
Extruded rubber seed oil extracted + lysine	39	1.49
+ lysine + tryptophan	40	1.45
Casein	112	2.54

a Protein in diet, 10.6%. Average initial weight, 45 g.

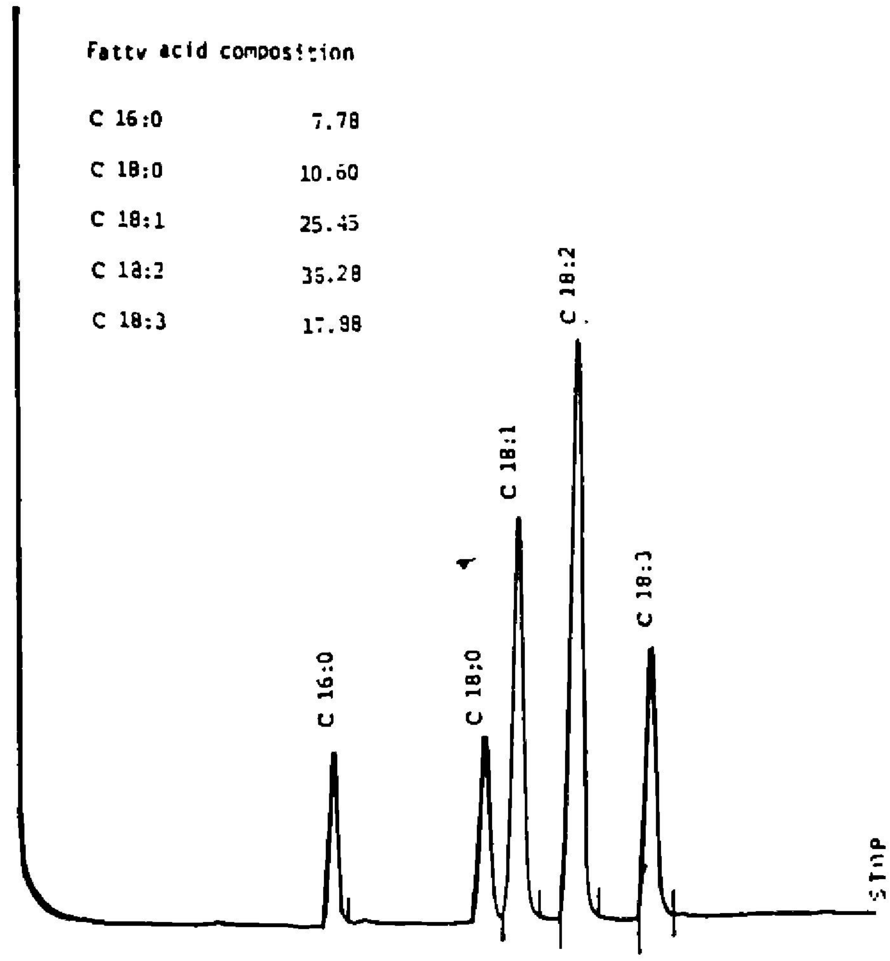

Fig. 1. Fatty acid composition of rubber seed oil.

Table 5. Physicochemical indices of rubber seed.

	Hydraulic press oil	Hexane extracted oil
Saponification value	196	208
Iodine value	131.7	141.4
Free fatty acids (ml KOH)	13.95	19.40

results shown in Table 6 were obtained. Weight gain as well as diet intake was inversely related to oil in the diet, and a 50 per cent mortality was observed when the diet contained 20 per cent rubber seed oil. Heating for 2 hours at 139-141°C and fed at the same level in the diet did not improve animal performance.

On a second biological experiment with adult rats, the results in Table 7 were recorded using a 10 per cent oil level in the diet. Weight performance was improved upon heating for 1 hour and, better still, with a 2-hour heat treatment, which resulted in values similar to those observed with cotton-seed oil. No differences were observed in food intake. The digestibility of the oil was also improved upon heating although not to the values obtained from cottonseed oil.

Discussion

The results of the present investigation show that the rubber seed is a good source of oil and protein which could play an important economic role in areas where the seed is available. On a dry matter basis it contains around 40 per cent fat and 16 per cent protein. These values differ from those reported by Giok *et al.* (11), who indicated oil to be about 32 per cent and protein about 27 per cent. From the point of view of utilization, the high moisture level of the seed is a disadvantage, since for any kind of processing, it would have to be dried. The results of the present study also differ from those by Giok *et al.* (11) on the cyanide content, which they reported as high as 330 mg/100 g. Extraction of the oil, however, decreases the values significantly.

Differences between this study and that reported by Giok *et al.* (11) were also found in essential amino acid content, particularly with respect to lysine and tryptophan, which were lower in the present study. On the other hand, other amino acid values are similar, including sulfur amino acids. The biological tests carried out, however, indicate that the protein of the rubber seed is deficient in lysine and no improvement was obtained in protein quality when methionine was added alone, or together with lysine. Tryptophan addition was also ineffective. The protein quality of the seed was relatively low and not improved by heating in the present study; however, Giok *et al.* (11) showed their material to be of a rather good quality. These differences suggest that the materials probably did not come from the same species, or that environmental conditions have a significant effect on the composition and quality of the protein.

Table 6. Effect of different levels of rubber seed oil on the growth of young rats.

Oil source	Treatment	Level in diet, g	Average weight gain, g[a]	Average feed consumed, g	Mortality
Soybean oil		20	120		0/8
Rubber seed oil	-	5	96	345	0/8
Rubber seed oil	–	10	59	254	0/8
Rubber seed oil	–	15	33	194	0/8
Rubber seed oil	–	20	13	171	4/8
Rubber seed oil	2 hr heat at 139-142°C	20	16	–	3/8

a 28-day experimental period.

Table 7. Adult rat performance and oil digestibility.

Oil source	Average weight gain, g[a]	Average feed intake, g	Digestibility %
Rubber seed oil (RSO)	40	74	83.8
RSO – 1 hr heating[b]	45	74	88.4
RSO – 2 hr heating[b]	62	74	93.0
Cottonseed oil (CSO)	65	74	97.9
CSO 1 hr heating[b]	61	75	94.7
CSO – 2 hr heating[b]	63	74	94.9

4 animals/group. 10%oil in basal diet.

a 28-day experimental period.

b 139-142°C.

The oil of the seed has been classified as a semidrying oil which may be used in the paint industry. However, it was of interest to test it for its nutritional value. The results indicate that when fed at a high level in the diet, it is toxic. No explanation can be given for such an effect. It may be possible that the oil used in the first study (Table 6) became oxidized or otherwise chemically altered due to the unsaturated nature of the oil, inducing lower weight performance and mortality in the experimental animals. It is well established that oxidation of fats and oils lowers their nutritional value and often produces toxic compounds. At the 10 per cent level and for adult rats, heating resulted in an improvement in performance, not only with respect to weight gain but also in its digestibility. Therefore, the utilization of the oil as a source of energy for animals should be further investigated, since if safe it could contribute to alleviate the shortage of energy for animal diets in Central America.

Summary

The production of rubber from the rubber three (*Hevea brasilensis*) is increasing in Central America. This implies a greater availability of the seed, at present utilized only to a very limited extent. This report presents chemical and biological information on the nutritional potential of the seed in animal nutrition. The raw dehydrated seed contains 17.6 per cent protein and 36.7 per cent crude oil. The amino acid content of the protein is deficient in lysine, which was confirmed by rat assays. Extrusion cooking improved the protein quality of the product and it is a useful process to remove HCN from the seed. The oil has a high concentration of C18:2 fatty acids with a digestibility of 84 per cent, which increased to 93 per cent upon heating. These values are slightly lower than those found for cottonseed oil. The results of the study suggest that the seed of the rubber tree has potential in animal nutrition and in the oil industry.

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