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NUTRIENTS IN NUTS

The Nutritive Value of Fresh and Roasted, California-Grown Nonpareil Almonds

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The effect of blanching and of dry-oven and oil roasting on the proximate composition, protein quality, calcium, phosphorus, iron, thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, folic acid, and biotin in California almonds of the Nonpareil variety was determined. The removal of the skins by the blanching process did not produce significant change in any of the nutrients measured, except for calcium and iron, which appear in greater amounts in the skin. Dry-oven roasting resulted in 69% loss of thiamine and 23% loss of pantothenic acid. There was additional loss of 15% of thiamine and 19% of pantothenic acid as a result of oil roasting. There was insignificant change in the other vitamins as a result of either type of roasting.

SEVERAL STUDIES of the B vitamins in California - grown products have been completed in this laboratory. A recent study included three varieties of walnuts (*9*). California also produces 80 to 100% of the almonds (*Prunus Amygdalus* Batsch) grown in the United States, and the Nonpareil (soft shell) variety represents a major part of this crop.

Few reports are available on the composition of known varieties of almonds. Early studies by Hart (*10*) and Pitman (*24*) reported the proximate composition of European and California almonds, but very little has been reported for the newer B vitamins—pantothenic acid, folic acid, vitamin B_6 (pyridoxine), and biotin. The values recorded for almonds in current food composition tables represent a compilation of the results of determinations of only a few nutrients, made in the various laboratories, and do not represent a complete analysis of any one sample of nuts. None of the tables contains values for almonds in the forms in which they are most frequently consumed—i.e., blanched, dry-oven, and oil-roasted.

The quality of almond protein has been studied by Morgan, Newbecker, and Bridge (*22*). Using mice as the experimental animals, these workers obtained a protein efficiency—grams gain per gram of protein eaten—of 0.63 on a diet containing 17.2% protein supplied by ether-extracted almond meal. Three rats fed almond residue proteins—fat-free almond meal from which the globulin protein had been extracted—at the 4.5% level, gained 3.8 grams per gram of protein eaten. The wide range between these values, the high level of protein in the diet fed the mice, and the small number of rats used in the experiment with almond residue proteins, leave doubts as to the significance of these results. Mitchell and Beadles (*21*) measured the biological value and digestibility of beef round and of five varieties of nuts, including almonds and English walnuts. Neither study measured the effect of roasting on the quality of protein in almonds. As heat is known to affect the nutritive value of protein, it seemed important to determine the effect of dry- and oil-roasting on the protein quality as well as on retention of the vitamins.

This study reports the proximate composition, including moisture, fat, and protein; protein efficiency as compared with that of English walnuts and beef;

total ash; calcium, phosphorus, and iron; and the vitamins thiamine, riboflavin, niacin, pantothenic acid, vitamin B_6, folic acid, and biotin. Newly harvested Nonpareil almonds, from the 1954 crop grown in the Sacramento area, were used for all experiments except for the bioassays of thiamine, in which two lots of 1956 crop nuts from the same area were used. The nuts were received shelled, and were blanched or roasted, either dry or in oil, as soon as possible. The final products, in a form ready for analysis, were packaged and placed in freezing storage until the analyses could be made.

Experimental Procedure

Preparation of Samples. The almonds were blanched by placing 100-gram portions in a wire basket and lowering them into a hot water bath at 80° to 90° C. for 3 minutes. Immediately after removal from the water bath, the skins (pellicle) were slipped off, and the almonds were spread on a blotter to dry at room temperature.

In order to approximate as nearly as possible the commercial method of dry-roasting, in which the almonds are roasted at about 145° C. for 30 minutes, the following procedure was adopted. The nuts were spread on a shallow tray to a depth of approximately 0.5 inch, placed in an electric oven preheated to 156° C., and heated for a total of 47 minutes. This period of time takes into account a drop in oven temperature of 16° in the first 17 minutes of heating. During the remaining 30 minutes, the temperature fluctuated between 140° and 150° C. as a result of opening the oven at 5-minute intervals for stirring to prevent uneven browning. The slightly browned color and the crispness of the roasted nuts were considered as evidence that these nuts had received an amount of heat comparable with that used on a commercial scale. The nut meats were removed from the oven and immediately spread out in thin layers to cool at room temperature.

For the oil-roasting process, the almonds were heated in a deep-fat fryer, using cottonseed oil. When the temperature of the oil reached 180° C., a basket containing 100 grams of blanched almonds was lowered into the oil. The temperature dropped to 150° C. and was maintained at 148° to 152° C. throughout the roasting time of 8 minutes. The nuts were removed, drained, and immediately spread out in a thin layer on a blotter, to cool at room temperature.

All of the almonds—unblanched, blanched, and blanched and roasted—were finely grated and sifted through a fine-mesh sieve. A grater was used instead of a food grinder because the latter tended to press out the oil. The thoroughly mixed, grated almonds were divided into representative samples, packaged in Pliofilm, and stored at a freezer temperature of −10° C. until the laboratory analyses could be made. All air drying and handling were done in a room away from sunlight in order to retain the light-sensitive vitamins.

Analytical Methods. The moisture, protein, and ash were determined by the methods described by Hall, Morgan, and Wheeler (*8*).

Fat was determined on dried, pulverized samples, using the Soxhlet method with petroleum ether.

Total carbohydrate was calculated by difference. The value reported for the blanched almonds is almost entirely utilizable carbohydrate while that reported for the unblanched nuts includes the fiber of the pellicle which constituted about 4.6% of the kernel.

Calcium was determined by the permanganate method, phosphorus by the microcolorimeter method of Briggs, and iron by the *o*-phenanthroline method, but using bipyridine. All of these methods are described by Jacobs (*16*).

The thiochrome procedure, a combination of the Hennessy and Cerecedo (*12*) and the Conner and Straub (*5*) methods, with modifications, was used for the determination of thiamine. After a series of experiments to determine the best method of extraction, as judged by recovery of known amounts of thiamine and by reproducibility of results, heating of the extract before enzyme digestion with clarase was omitted and Decalso absorption for purification was used. Thiamine was also determined biologically in unblanched and blanched almonds by the method described by Jentsch and Morgan (*18*).

The riboflavin values shown in Table I were determined by the microbiological method of Snell and Strong (*26*), using *L. casei* as the test organism. Values thus obtained for the unblanched, blanched, and blanched, dry-roasted almonds were 75, 74, and 69%, respectively, of values found by a rat bioassay made on the nuts.

Niacin was determined by the method of Snell and Wright (*27*).

Vitamin B_6 (pyridoxine, pyridoxamine, and pyridoxal) was determined by the method of Atkin and coworkers (*2*), using *S. carlsbergenesis* as the test organism. Extraction was made by autoclaving at 15 pounds' pressure for 5 hours in 0.05*N* hydrochloric acid. A bioassay for this vitamin, made by the procedure described by Hall and coworkers (*9*), showed good agreement with the values obtained by the microbiological procedure.

Table I. Average[a] Composition of Variously Processed Almonds on a Fresh-Weight Basis

	Unblanched		Blanched		Dry-Roasted		Oil-Roasted	
	Average	Range	Average	Range	Average	Range	Average	Range
				Per Cent				
Water	3.3	2.9 – 3.4	5.4	4.7 – 5.9	2.0	1.5 – 2.5	0.7	0.5 – 0.8
Protein[b]	20.1	19.9 –20.3	20.2	20.0 –20.5	21.0	20.9 –21.1	20.9	20.7 –21.0
Fat	53.2	53.4 –53.7	54.6	54.2 –54.9	56.8	56.3 –57.2	58.6	57.9 –59.5
Carbohydrate[c]	20.4	...	16.9	...	17.2	...	16.8	...
Ash	3.0	2.9 – 3.1	2.8	2.7 – 2.9	3.0	2.9 – 3.1	3.0	2.9 – 3.1
				Milligrams Per Cent				
Calcium	290	283 – 301	273	261 – 281	...	...	...	...
Phosphorus	477	444 – 506	487	475 – 502	...	...	...	...
Iron	4.5	3.8 – 4.9	4.3	4.0 – 5.1	...	...	...	...
Thiamine	0.21	0.19 – 0.25	0.23	0.21 – 0.27	0.07	0.06 – 0.08	0.04	0.03 – 0.05
Riboflavin	1.07	1.01 – 1.12	1.06	1.00 – 1.16	0.98	0.91 – 1.07	1.06	1.02 – 1.13
Niacin	3.49	3.29 – 3.74	3.42	3.41 – 3.50	3.43	3.35 – 3.56	3.56	3.42 – 3.74
Pyridoxine	0.10	0.09 – 0.12	0.09	0.08 – 0.11	0.10	0.08 – 0.13	0.09	0.08 – 0.11
Pantothenic acid[d]	0.37	0.36 – 0.38	0.35	0.31 – 0.43	0.28	0.27 – 0.29	0.21	0.18 – 0.24
Folic acid	0.12	0.11 – 0.13	0.11	0.09 – 0.14	0.13	0.11 – 0.13	0.11	0.10 – 0.13
Biotin	0.018	0.015– 0.019	0.019	0.018– 0.021	0.019	0.018– 0.021	0.018	0.016– 0.019

[a] Each average value represents 8 to 12 separate determinations.
[b] Protein = N × 5.18.
[c] By difference.
[d] Mylase-P was used in the extraction.

Pantothenic acid was measured by the microbiological procedure of Skeggs and Wright (*25*). The extraction was made by the method of Ives and Strong (*15*), using Mylase-P in acetate buffer.

Folic acid was determined by the method of Mims and Laskowski (*20*), using chicken pancreas enzyme for digestion of the samples and *S. faecalis* (ATCC) 8043 as the test organism.

Biotin was measured by the procedure of Wright and Skeggs (*30*), with *L. arabinosus* as the test organism. The samples were autoclaved for 2 hours at 15 pounds pressure in 2*N* sulfuric acid for extraction.

The protein efficiency—i.e., weight gain per gram of protein eaten—was determined as a measure of the quality of the protein in the variously processed almonds, and compared with that of English walnuts and of beef muscle.

Two sets of experiments of 28 days each were carried out. In each experiment, weanling rats of the Long-Evans strain were caged separately and fed a purified diet containing 22% casein, until they attained weights between 50 and 60 grams. They were then divided into 4 groups, of 9 to 11 animals each, in which the sexes and litters were evenly distributed and fed the experimental diets. In order to equalize the protein intake in all of the groups, the same amount of food was fed to each rat, the amount being determined by the group of rats eating the smallest amount of food. Those running out of food before others had consumed the weekly amount allotted were fed a small amount of basal protein-free diet to finish out the week.

The diets fed had the following composition: salt mix, Hubbell, Mendel, and Wakeman (*14*), 4%; hydrogen fat, taking into account the fat remaining in the nuts, to make 20%; protein, 12% supplied by one of the following foods: defatted beef muscle, and the partially defatted almond and English walnut meals; and cornstarch to make 100%.

The defatted beef muscle used in both of these experiments was prepared commercially by dehydration and benzol extraction as described by Hawley *et al.* (*11*).

The partially defatted almond meals fed in experiment 1 were prepared as follows: The blanched nuts were ground once in a food chopper and dried in a dehydrator for 1 hour at 60° C. They were reground and dried as before for 2 hours, and cooled at room temperature. The fat was removed from the meal by pressing out the oil in a Carver hand press. The meal was divided into two portions. One portion was fed as meal; the other was placed in shallow pans and toasted, with stirring at 5-minute intervals, for 35 minutes in an electric oven at temperatures ranging between 155° and 160° C. The percentage of fat in the untoasted and toasted meals was 31 and 26, respectively.

The English walnuts were blanched in hot water at 90° C. for approximately 3 minutes, and the skins were then peeled off. The peeled kernels were ground and dried, and the oil was pressed out in the same manner as for almonds.

In experiment 2, the blanched, blanched dry-roasted, and blanched oil-roasted almonds, prepared in the same way as those used for the proximate analysis and mineral and vitamin assays, were ground and dried as described for those fed in experiment 1. The oil was not pressed out, and the nuts were extracted in a Soxhlet apparatus with petroleum ether for approximately 12 hours. The meal was spread out in a thin layer until the ether was completely evaporated.

A mixture of cod liver oil, carotene, and mixed tocopherols, providing daily 10 and 100 I.U. of vitamins D and A, respectively, and 1 mg. of mixed tocopherols, was fed three times a week. A solution of B vitamins and Menadione, fed three times weekly, provided daily: thiamine hydrochloride, 20 γ; riboflavin, 40 γ; pyridoxine hydrochloride, 20 γ; calcium pantothenate, 100 γ; niacinamide, 66 γ; inositol, 2.5 mg.; biotin, 2 γ; *p*-aminobenzoic acid, 100 γ; folic acid, 20 γ; choline, 10 mg.; and vitamin K, 49 γ.

Table II. Average Water, Ash, Mineral, and Thiamine Content of Almond Skins[a]

(All values are given on a fresh-weight basis)

	Average	Range	No. of Detns.
Water, %	9.4	8.0–10.3	8
Ash, %	3.4	3.2–3.6	8
Calcium, mg.%	620	575–878	10
Phosphorus, mg.%	172	159–196	6
Iron, mg.%	9.3	7.5–10.2	8
Thiamine, mg.%	0.047	0.035–0.056	6

[a] Skins constitute about 4.6% of the whole kernel.

Results and Discussion

Table I summarizes the proximate analyses of the unblanched, blanched, and blanched dry- or oil-roasted almonds and their minerals and B-vitamin content. Table II shows the moisture, total ash, mineral, and thiamine content of the pellicle (skins).

Slight changes in the percentage of moisture show an increase in the blanched nuts as a result of absorption of the blanching water, and decreases in the roasted nuts as a result of the heat treatment. The dry-roasted nuts had a slightly higher percentage of fat and a lower percentage of moisture. The greater increase in percentage of fat in the oil-roasted nuts may be accounted for by absorption of oil used in roasting and also, to some degree, by a greater loss of moisture. The slight differences in the percentage of protein reflect the changes in water and fat content.

On the fresh-weight basis, the average percentages of total ash were 3.0, 2.8, 3.0, and 3.0 mg. %, respectively, for the unblanched, blanched, blanched dry- and oil-roasted almonds. On the dry-weight basis, these percentages were 3.2, 3.0, 3.0, and 3.0, respectively. The decrease in ash in the blanched and blanched roasted nuts can be attributed to loss by removal of the skins which constitute approximately 4.6% of the kernel and which contained 3.4% ash.

The concentration of iron and calcium in the skins is two to three times that in the kernel, and would account for the decreased percentages of these two minerals in the blanched almonds (Table I). The percentage of phosphorus in skin is less than half that in the kernel, which would account for the slightly higher percentage of phosphorus in the blanched almond (Table I). The roasting process did not affect the mineral content of the blanched nuts.

The amounts of thiamine, riboflavin, niacin, vitamin B_6, pantothenic acid, biotin, and folic acid in the variously processed almonds are given in Table I.

The blanching process caused insignificant changes in the values of all vitamins except possibly thiamine. The blanched nuts contained 0.23 mg. % and the unblanched nuts, 0.21 mg. % of thiamine. Calculation of t on the basis of the means of the two samples gave the value of 2.2, $P = 0.05$, which is of possible but of dubious significance. The average thiamine content of the skin (Table II) was 0.047 mg. %. Considering the small percentage of the kernel that is skin, this would not account for as much increase of thiamine as in the blanched nuts. There was also the possibility that the skins of the almonds might contain substances which interfere with the chemical determination of this vitamin and possibly with its biological utilization. In order to answer these questions and also to compare the thiamine values measured

Table III. Average Thiamine Content of Unblanched and Blanched Almonds of Two Lots of 1956 Crop Nonpareil Variety

Type of Almonds and Lot No.	Thiamine Content, Measured by Bioassay: No. rats per group	Bioassay: Mg.%	Thiochrome: No. of determinations	Thiochrome: Mg.% av.	Thiochrome: Range	Thiochrome: % bioassay value
Lot 1						
Unblanched	12	0.35	10	0.24	0.21–0.27	68
Blanched	12	0.37	10	0.25	0.21–0.28	67
Lot 2						
Unblanched	12	0.30	8	0.20	0.17–0.24	66
Blanched	12	0.30	8	0.20	0.18–0.23	66

Table IV. Comparison of Amounts of B Vitamins in Roasted and Unroasted Blanched Almonds

(Calculated on dry-weight basis as percentage of the value of blanched almonds)

Type of Roasting	Thiamine, %	Riboflavin, %	Niacin, %	Vitamin B_6, %	Pantothenic Acid, %	Folic Acid, %	Biotin, %
Dry	31	89	97	95	77	109	111
Oil	16	96	99	92	56	93	100

Table V. Comparison of Nutritive Value of Unblanched Nonpareil Almonds, as Determined in Current Study, with Published Values of Almonds and Other Commonly Consumed Nuts

Kind of Nut	Per Cent: Protein	Per Cent: Fat	Per Cent: Ash	Milligrams Per Cent: Ca	P	Fe	Thiamine	Riboflavin	Niacin
Almonds[a]	20.1	53.2	3.0	290	492	4.5	0.21	1.07	3.49
Almonds[b]	18.6	54.1	3.0	254	475	4.4	0.25	0.67	4.6
Cashews[b]	18.5	48.2	2.7	46	428	5.0	0.63	0.19	2.1
Peanuts[b]	26.9	44.2	2.7	74	393	1.9	0.30	0.13	16.2
Pecans[b]	9.4	73.0	1.6	74	324	2.4	0.72	0.11	0.9
English walnuts[b]	15.0	64.4	1.7	83	380	2.1	0.48	0.13	1.2
English walnuts[c]									
Payne	16.2	69.1	..	..	..	..	0.28	0.17	1.17
Placentia	14.9	70.1	..	..	..	..	0.26	0.17	1.23
Franquette	14.8	70.4	..	..	..	..	0.24	0.14	0.89

[a] Values found in this study.
[b] Watt and Merrill (*29*).
[c] Hall *et al.* (*9*).

chemically with those measured biologically, two new lots of Nonpareil almonds of the 1956 crop were obtained from the same area as those of the 1954 crop. These lots of nuts were obtained at two different times and did not come from the same orchard. The results of the bioassay and of a thiochrome assay of the thiamine in these nuts are given in Table III. The difference in the blanched and unblanched almonds was of slight but doubtful significance.

The wide variation of the individual determinations of the thiamine and the fact that, in lot 2, the amount of thiamine was the same in both the unblanched and blanched nuts, support the conclusion that there is no real difference in the amount of thiamine in the blanched and unblanched almonds. Where there was a slight difference in the thiamine content of these nuts when measured chemically, the same difference existed between the two samples when fed to rats.

These findings show that the skins do not contain a substance which interferes with the chemical determination of this vitamin and that there was nothing in them to interfere with the biological utilization of thiamine in the unblanched nuts. A bioassay of the skins alone would have given a better measure of the biological utilization of the thiamine, but because the thiamine content of the skins is very low, it was impossible for the rats to eat a sufficient amount to carry out the assay. In all cases the amounts of thiamine found by chemical measure were 66 to 68% of those found by bioassay.

The amounts of B vitamins of dry- and oil-roasted almonds, compared on a dry-weight basis with blanched almonds, are given in Table IV. The slightly higher amounts of folic acid and of biotin probably indicate that the heat treatment may have increased the ease of extraction of these vitamins or may otherwise have increased their availability to the organisms.

There was 15% less thiamine and 19% less pantothenic acid in the oil-roasted than in the dry-roasted nuts. There was no significant difference in the riboflavin, niacin, vitamin B_6, folic acid, and biotin content. The method of oil-roasting of almonds is used commercially in order to shorten the roasting time and increase the flavor and aroma of the nuts. No values have been published showing the effect of oil-roasting on the vitamins in any kind of nuts.

Fournier *et al.* (*7*) demonstrated that the loss of thiamine in dry, oven-roasted peanuts at 155° to 160° C. was not significant in the first 5 minutes of roasting owing to the fact that some time is required for the heat to rise to the temperature at which this vitamin is destroyed. After the first 5 minutes, the thiamine was destroyed rapidly. Pickett (*23*) found that, in peanut butter, the maximum rate of destruction occurred early in the heating process, especially when the temperature reached 147° C. and above. He also related lower thiamine values to a darker color in peanut butter. The color of the oil-roasted almonds was darker than those which were dry-roasted. As the maximum temperature is achieved more rapidly in the oil-roasted nuts, the greater loss of this vitamin could be expected as result of oil-roasting almonds at about 150° C. for only 8 minutes.

The 19% greater loss of pantothenic acid which occurred in the oil-roasted almonds can also be explained on the same basis as the loss of thiamine during this kind of processing.

The 11% loss of riboflavin in the dry-roasted almonds is close to the limits of experimental error and is probably not significant. There was no loss of this vitamin during the oil-roasting process. Dunn and Goddard (*6*) found significant loss of this vitamin in peanuts roasted at 180° C. for 40 minutes, but none in those roasted at 160° C. However, those results and the trends shown in this study indicate loss of riboflavin could likely occur in almonds if they were roasted at temperatures in excess of those used in the present experiment—that is, 145° C. for 30 minutes.

The nutrient content of the unblanched Nonpareil almonds reported in this study is given in Table V along with the values for the same nutrients reported by Watt and Merrill (*29*) for almonds of unspecified variety and for other commonly used nuts. The published values for almonds agree well with respect to all nutrients except riboflavin, which was found to be 1.07 mg. % in this study as compared with 0.67 mg. % given by Watt and Merrill. A bioassay made on the same sample of nuts in this laboratory gave a value of 1.44 mg. % of riboflavin. Bioassays commonly run higher than microbiological assays, and this value would give support to the higher value for

riboflavin in the Nonpareil nuts. On the basis of the values found in this laboratory, almonds contain eight to 10 times more riboflavin than do all other nuts.

Wide variation is shown in the composition of different kinds of nuts. In comparison with cashew nuts, peanuts, pecans, and English walnuts, almonds have a medium amount of protein and fat; peanuts are highest in protein and lowest in fat; and pecans are lowest in protein and highest in fat.

Almonds have the largest amount of calcium of all the nuts—about four times the amount present in peanuts, pecans, and English walnuts, and seven times the amount in cashew nuts. Almonds and cashew nuts contain about one fourth more phosphorus and twice as much iron as peanuts, pecans, and English walnuts.

The thiamine content of almonds is lowest of all the nuts. A small amount of thiamine is found in almond skins—0.047 mg. %—as compared with thiamine values of 7.9 mg. % in peanut skins, determined by bioassay [Booher and Hartzler (*3*)] and of 3.6 mg. % reported by Higgins *et al.* (*13*), determined chemically.

Peanuts contain five times more niacin than do almonds, but almonds are a considerably better source of this vitamin than any of the other nuts.

Values for pantothenic acid, vitamin B_6, folic acid, and biotin are not included in the Watt and Merrill food composition tables (*29*). A summary of available values for these vitamins in almonds and other nuts, as published by other laboratories, may be found in Table VI.

The pantothenic acid content of the almonds agrees with the concentration reported by Asenjo and Muñiz (*1*) for tropical almonds (*Terminalia Catappa* L.). This value is five times as much as reported by James (*17*) and 10 times that reported by Jukes (*19*) by chick assay. Zook, MacArthur, and Toepfer (*31*) published results of 0.281 mg. % for free and 0.578 mg. % for total pantothenic acid in almonds obtained from California, but did not specify the variety nor locality in which they were grown. Neither did they indicate whether or not the nuts used were unblanched, blanched, or roasted. These workers determined free pantothenic acid in an extract using a double enzyme treatment with intestinal phosphatase and pigeon liver extract. The value of 0.37 mg. % found in this study, by extraction with Mylase-P is, according to Zook *et al.*, higher than the free pantothenic acid but short of the value they obtained for total pantothenic acid. Pilot studies made in this laboratory with alkaline phosphatase and chicken liver enzyme gave such varying results that this method was abandoned in favor of the use of Mylase-P in extraction.

No published values for vitamin B_6 in almonds are available for comparison. There is about one tenth the amount found in walnuts (*9*), and about one third that reported for peanuts by Higgins *et al.* (*13*).

The folic acid concentration is twice that reported by Toepfer *et al.* (*28*) for almonds purchased in a Washington market. Nonpareil almonds contain about the same amount of this vitamin as is found in Franquette walnuts, but less than that in the Payne and Placentia walnuts (*9*) and one half that reported for peanuts (*13*).

The biotin content is about four times that reported for almonds by James (*17*) and about one half the amount reported for peanuts by Higgins *et al.* (*13*).

Values for niacin, pantothenic acid, and biotin, reported by James (*17*) for peeled almonds grown in England, are all lower than those obtained for Nonpareil almonds in this laboratory. The analyses for these three vitamins were all made on one extract in the English study, which may account for these differences.

The protein efficiencies of the nuts and beef proteins are given in Table VII.

In experiment 1, in which the protein efficiency of the proteins in beef, in unblanched and blanched, toasted almonds, and in English walnuts were measured, the blanched almonds and English walnuts had practically identical values, 1.62 ± 0.15 and 1.60 ± 0.14, respectively. The protein efficiency of the beef muscle protein was 2.47 ± 0.09, or approximately 35% higher than that of either of the nuts. In experiment 2, the protein efficiency of the blanched almonds was the same as before, but that of the beef was about 42% higher than that of the blanched almonds. No significance is attached to the apparently higher quality of the beef in the later experiment as cross-comparisons

Table VI. Summary of Published Values of Pantothenic Acid, Vitamin B_6, Folic Acid, and Biotin in Almonds, Walnuts, and Peanuts, and Sources for These Values

Kind of Nut	Pantothenic Acid, Mg.%	Vitamin B_6, Mg.%	Folic Acid, Mg.%	Biotin, γ/100 G.	Source of Values
Almonds					
Nonpareil, unblanched	0.37	0.10	0.12	17.8	This study
Washington market	...	..	0.05	..	Toepfer *et al.* (*28*)
Washington market	0.281 (free)	..	..	..	Zook *et al.* (*31*)
	0.578 (total)	..	..	..	
Market	0.03[a]	..	..	..	Jukes (*19*)
Tropical	0.41	..	..	..	Asenjo and Muñiz (*1*)
Peeled	0.08	..	..	0.4	James (*17*)
Walnuts					
Payne and Placentia	0.74	1.00	0.22	..	Hall *et al.* (*9*)
Franquette	0.51	0.87	0.13	..	Hall *et al.* (*9*)
Peanuts	2.5	0.30	0.28	34	Cheldelin and Williams (*4*)

[a] Chick assay.

Table VII. Protein Efficiency of Proteins in Beef, English Walnuts, and Almonds When Blanched, Blanched Toasted, Blanched Dry-Roasted, and Blanched Oil-Roasted

Source and Treatment of Protein	No. of Rats per Group	Weight Gain in 28 Days, G.	Total Protein Intake, G.[a]	Protein Efficiency
Experiment 1. Almonds Defatted by Hand Press				
Beef	10	46	18.64	2.47 ± 0.09[b]
Blanched almonds	9	23	14.19	1.62 ± 0.15
Blanched toasted almonds[c]	10	3	12.90	0.24 ± 0.07
English walnuts	9	22	14.02	1.60 ± 0.14
Experiment 2. Almonds Defatted by Ether Extraction				
Beef	10	66	23.6	2.80 ± 0.08
Blanched almonds	10	37	22.6	1.61 ± 0.08
Blanched almonds, dry-roasted[d]	11	26	22.9	1.12 ± 0.05
Blanched almonds, oil-roasted[d]	11	23	22.1	1.05 ± 0.19

[a] The factors used for calculation of protein from nitrogen were: beef, 6.25; almonds, 5.18; and English walnuts, 5.29.

[b] Standard error calculated by the method of Snedecor by the formula $sx = \frac{s}{n}$, where s is the standard deviation and n is the number of observations.

[c] The almonds were finely ground before toasting.

[d] The almonds were roasted before being ground to incorporate into the diet.

of two different groups of animals run at different times are not justifiable. In both experiments, however, the quality of the protein in the beef was significantly higher than that of the nuts. Mitchell and Beadles (*21*) obtained a biological value for beef protein which was 32% higher than that of almonds and 26% higher than that of English walnuts. Almond protein was about 94% as digestible as English walnut protein, and 84% as digestible as beef protein. Allowing for possible varietal differences in the nuts used by these workers, and for the variation in values measured by these two methods of study, the relative differences in the protein qualities of these foods, as measured by the protein efficiency, are quite comparable with those measured by the nitrogen balance method.

As the dehydrated beef used for these experiments had been defatted, the nuts were also defatted. In experiment 1, the fat was pressed out of the almonds by a hand press, leaving about 26 and 31% of the fat in the unblanched and blanched almonds, respectively. A power press was no more effective in removing the fat than was the hand press. In experiment 2, the fat was removed by ether extraction, and can be presumed to have been completely removed. As the protein efficiency of the blanched almonds was practically the same in both experiments, the removal of the fat made no difference in the utilization of the protein for growth. No difference would be expected, however, because the fat level, and thus the caloric value of all diets, was kept at the same level. Obviously, no toxic effect resulted from the use of ether in the extraction process.

The protein efficiency values for the protein in toasted almonds, experiment 1, and the dry- and oil-roasted almonds in experiment 2 were 0.24 ± 0.07, 1.12 ± 0.05, and 1.05 ± 0.19, respectively. The 85% decrease in protein efficiency in the toasted almonds, as compared with a decrease of 30% in those dry-roasted in experiment 2, is probably due in part to the greater intensity of heat used in preparation of the former and also to the fact that they were finely ground before toasting, thus exposing greater surface area to the heat and resulting in a greater degree of browning. Those which were dry-roasted were roasted before grinding, and the resultant meal was not so brown. The difference in the protein efficiency of these two types of roasted nuts is of high statistical significance. The 35% decrease in protein efficiency in the oil-roasted almonds is slightly greater than that found in the dry-roasted nuts. However, the difference in protein efficiency between these two types of roasted nuts is small and of doubtful significance.

The greater damage by heat to the toasted ground nuts is more of academic than of practical interest as this method of roasting will probably only rarely be used. This experiment does point out the dangers of such practices. The extent of the loss in almonds subjected to the dry- and oil-roasting method, comparable with commercial methods of roasting, is of real concern to consumers, especially those who use this type of nuts as the chief source of dietary protein. Mitchell and Beadles (*21*) have found that a slight but significant decrease occurs in the biological value of peanuts roasted by a commercial method. This decrease is considerably less than that found in almonds by the growth method of measuring protein quality if one assumes that the same magnitude of difference would be shown equally by the two methods of measure of protein quality.

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Mechanism of Browning of Ascorbic Acid-Citric Acid-Glycine Systems—Correction

On page 137 in our recent article [J. AGR. FOOD CHEM. **6,** 135–9 (1958)], the figure caption should read "Figure 3. Rate of carbon dioxide production"; the caption for the upper figure, page 138, should read "Figure 2. Rate of increase in absorbance"; and the caption for the lower figure, page 138, should read "Figure 4. Carbon dioxide production relative to browning." With these corrections, the figures as cited in the text are correct.

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