this high steam rate, 3½ theoretical stages are required. Deodorizers designed for hexane stripping probably do not provide more than 2 theoretical stages. Alcohol strippers will have to do better, but they will probably not provide more than 3½ theoretical stages. The proposed steam flow of 1 kg/kg water in the stripped flakes is realistic.

Aside from possible reduction of protein denaturation, little advantage can be found for vacuum stripping, since the y-x diagram for ethanol-water is not sensitive to pressure.

## DISCUSSION

As yet little commercial experience in recovering aqueous solvents from oilseeds exists. When equipment will be needed to do so, its design should be based on previous experience in the oilseed industry and on rational consideration of the properties of aqueous solvents and their interaction with oilseed components. Better physicochemical data are needed than is now available.

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[Received September 22, 1983]

# Oil Content and Fatty Acid Composition of Peanuts Imported into Japan

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## ABSTRACT

The oil content and fatty acid composition of Virginia, Runner, and Spanish market types of peanuts imported into Japan were determined. The significant differences among the countries of production were shown in stearic, eicosenoic and lignoceric acid contents of Virginia market type and oil content and palmitic, stearic, oleic, linoleic, eicosenoic, behenic and lignoceric acid contents of Spanish market type. The Spanish market type, as compared with the Virginia market type, was significantly higher in palmitic, stearic, linoleic, arachidic and behenic acid contents and lower in oleic, eicosenoic and lignoceric acid contents on the gross samples.

## INTRODUCTION

In Japan, 38,550 tons of shelled peanuts (Virginia market type, 35,740 tons, and Spanish market type, 2,810 tons) were harvested in 1981. A total of 51,300 tons of shelled peanuts (Virginia market type, 21,000 tons, and Spanish and Runner market types, 30,300 tons) were imported in 1982. Thus, about 60% of the consumption depended on foreign trade. Imports were primarily from China and the U.S.A. for the Virginia market type, China and South Africa for the Spanish market type, and the U.S.A. for the Runner market type. About two-thirds of the world's peanut crop is crushed for oil. In Japan, however, peanuts are used mostly for food products: salted peanuts, peanuts roasted in-shell, confectionaries and peanut butter. As to the effect on products of fatty acid composition, high linoleic acid content decreases the shelf life because of a negative correlation between linoleic acid content and oil stability (1). The wider ratio of oleic acid to linoleic acid in peanut oil was considered as an indicator of more stable oil (2-4). From the standpoint of the nutrition, high linoleic acid content is desirable because the acid, in addition to being an essential fatty acid, has a hypocholesterolemic effect (lowering of blood cholesterol) (5). In previous studies, it was shown that the fatty acid composition of peanuts was affected by growing location in Japan, and the oil content and fatty acid composition were correlated with daily mean temperature during the ripening period (6). Holaday and Pearson (7) also reported the U.S.A. location where peanuts were grown significantly affected their fatty acid composition; and a significant correlation also exists between the mean temperature during the growth period and the level of major fatty acid contents. This suggested that the oil content and fatty acid composition of peanuts imported into Japan may vary by the countries of production because of different varieties and also different growth temperatures. Therefore, investigations were undertaken to study the oil content and fatty acid composition of peanuts imported into Japan.

## EXPERIMENTAL

### Materials

Three market type peanuts imported into Japan were collected in 1982. These were as follows: Virginia market type, 16 samples from 3 countries (China, U.S.A. and Australia); Runner market type, 5 samples of variety Florunner from the U.S.A., and Spanish market type, 37 samples from 8 countries (China, Thailand, Argentina, Paraguay, Brazil, Sudan, South Africa and Australia).

### Analytical Procedure

Skins (seed coats) were removed and kernels were crushed in a mortar with a pestle. Oil was extracted from the crushed sample on a Butt type extractor with diethyl ether as a solvent. Fatty acids in the oil were determined by gas chromatography after transesterification to their methyl ester by the boron trifluoride method as outlined by the Association of Official Analytical Chemists (8). Esters were separated by using a Shimadzu GC-6APF chromatograph equipped with a FID and 3 mm × 3 m glass column packed with Unisol 3000 Uniport C, 80-100 mesh (Gasukurokogyo Co., Ltd.). The column temperature was 240 C, and the

**TABLE I**

**100-Seed-Weight, Oil Content and Fatty Acid Composition of Virginia, Runner and Spanish Market Types of Peanuts[a]**

| Country | 100-seed-wt (g) | Oil (% of dry wt) | Fatty acid (wt % of total acids) | | | | | | | | | | 18:1 /18:2 ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 16:0 | 16:1 | 18:0 | 18:1 | 18:2 | 18:3 | 20:0 | 20:1 | 22:0 | 24:0 | |
| **Virginia Market Type** | | | | | | | | | | | | | |
| China (n=7) | | | | | | | | | | | | | |
| Minimum | 66 | 46.5 | 9.3 | 0.0 | 2.7 | 47.1 | 28.5 | 0.1 | 1.4 | 1.2 | 2.7 | 1.5 | 1.47 |
| Maximum | 104 | 53.8 | 10.2 | 0.1 | 3.7 | 51.0 | 32.1 | 0.2 | 1.7 | 1.4 | 3.3 | 1.7 | 1.79 |
| Mean | 84.1 | 50.20 | 9.67 | 0.09 | 3.23 | 48.66 | 30.69 | 0.19 | 1.54 | 1.33 | 3.03 | 1.59 | 1.589 |
| U.S.A. (n=7) | | | | | | | | | | | | | |
| Minimum | 58 | 49.4 | 8.8 | 0.1 | 2.2 | 45.9 | 28.6 | 0.1 | 1.2 | 1.2 | 2.9 | 1.7 | 1.36 |
| Maximum | 89 | 53.4 | 10.2 | 0.2 | 3.0 | 49.8 | 33.7 | 0.2 | 1.7 | 1.8 | 3.7 | 2.0 | 1.68 |
| Mean | 70.4 | 51.29 | 9.46 | 0.11 | 2.59 | 47.47 | 32.09 | 0.19 | 1.43 | 1.54 | 3.31 | 1.86 | 1.484 |
| Australia (n=2) | | | | | | | | | | | | | |
| Minimum | 71 | 49.6 | 8.8 | 0.1 | 2.4 | 48.7 | 30.2 | 0.2 | 1.3 | 1.6 | 3.2 | 1.8 | 1.53 |
| Maximum | 73 | 53.0 | 8.9 | 0.1 | 2.5 | 49.4 | 31.8 | 0.2 | 1.7 | 1.8 | 3.5 | 1.9 | 1.64 |
| Mean | 72.0 | 51.30 | 8.85 | 0.10 | 2.45 | 49.05 | 31.00 | 0.20 | 1.50 | 1.70 | 3.35 | 1.85 | 1.585 |
| 3 countries (n=16) | | | | | | | | | | | | | |
| Minimum | 58 | 46.5 | 8.8 | 0.0 | 2.2 | 45.9 | 28.5 | 0.1 | 1.2 | 1.2 | 2.7 | 1.5 | 1.36 |
| Maximum | 104 | 53.8 | 10.2 | 0.2 | 3.7 | 51.0 | 33.7 | 0.2 | 1.7 | 1.8 | 3.7 | 2.0 | 1.79 |
| Mean | 76.6 | 50.81 | 9.48 | 0.10 | 2.85 | 48.19 | 31.34 | 0.19 | 1.49 | 1.47 | 3.19 | 1.74 | 1.543 |
| Diff. among countries | n.s. | n.s. | n.s. | n.s. | * | n.s. | n.s. | n.s. | n.s. | * | n.s. | ** | n.s. |
| **Runner Market Type** | | | | | | | | | | | | | |
| U.S.A. (n=5) | | | | | | | | | | | | | |
| Minimum | 40 | 47.4 | 9.4 | 0.1 | 2.0 | 45.1 | 27.6 | 0.1 | 1.1 | 1.5 | 3.3 | 1.9 | 1.33 |
| Maximum | 51 | 52.0 | 10.1 | 0.2 | 2.6 | 51.4 | 33.8 | 0.2 | 1.5 | 1.9 | 3.9 | 2.1 | 1.86 |
| Mean | 43.6 | 50.48 | 9.78 | 0.12 | 2.30 | 48.40 | 30.60 | 0.18 | 1.32 | 1.68 | 3.60 | 2.00 | 1.592 |
| **Spanish Market Type** | | | | | | | | | | | | | |
| China (n=7) | | | | | | | | | | | | | |
| Minimum | 42 | 47.4 | 10.2 | 0.1 | 3.1 | 36.4 | 35.7 | 0.2 | 1.6 | 1.1 | 3.4 | 1.4 | 0.90 |
| Maximum | 51 | 54.0 | 11.7 | 0.2 | 4.6 | 40.7 | 40.3 | 0.3 | 2.1 | 1.4 | 4.4 | 1.9 | 1.14 |
| Mean | 44.9 | 51.17 | 10.94 | 0.11 | 3.73 | 38.04 | 38.43 | 0.21 | 1.80 | 1.26 | 3.89 | 1.63 | 0.990 |
| Thailand (n=2) | | | | | | | | | | | | | |
| Minimum | 43 | 50.3 | 12.6 | 0.1 | 4.1 | 39.9 | 34.4 | 0.1 | 1.7 | 0.8 | 3.3 | 1.2 | 1.11 |
| Maximum | 44 | 50.8 | 12.7 | 0.1 | 4.3 | 41.3 | 35.9 | 0.2 | 1.7 | 0.9 | 3.5 | 1.3 | 1.20 |
| Mean | 43.5 | 50.55 | 12.65 | 0.10 | 4.20 | 40.60 | 35.15 | 0.15 | 1.70 | 0.85 | 3.40 | 1.25 | 1.155 |
| Argentina (n=5) | | | | | | | | | | | | | |
| Minimum | 36 | 46.9 | 9.8 | 0.1 | 3.0 | 39.4 | 35.2 | 0.2 | 1.4 | 1.1 | 3.5 | 1.7 | 1.02 |
| Maximum | 44 | 48.9 | 10.8 | 0.1 | 4.3 | 41.4 | 38.7 | 0.2 | 1.9 | 1.4 | 3.9 | 1.8 | 1.17 |
| Mean | 39.2 | 47.86 | 10.38 | 0.10 | 3.64 | 40.60 | 36.74 | 0.20 | 1.68 | 1.22 | 3.74 | 1.78 | 1.108 |
| Paraguay (n=5) | | | | | | | | | | | | | |
| Minimum | 32 | 49.3 | 11.5 | 0.1 | 3.6 | 43.2 | 30.2 | 0.2 | 1.4 | 0.9 | 3.2 | 1.4 | 1.30 |
| Maximum | 44 | 55.2 | 13.7 | 0.2 | 4.0 | 44.8 | 33.3 | 0.2 | 1.8 | 1.0 | 3.6 | 1.5 | 1.48 |
| Mean | 35.4 | 51.30 | 12.96 | 0.14 | 3.78 | 44.16 | 31.42 | 0.20 | 1.58 | 0.94 | 3.38 | 1.44 | 1.406 |
| Brazil (n=3) | | | | | | | | | | | | | |
| Minimum | 42 | 50.8 | 11.4 | 0.1 | 3.3 | 41.4 | 34.3 | 0.1 | 1.5 | 1.0 | 3.4 | 1.4 | 1.16 |
| Maximum | 46 | 53.0 | 11.9 | 0.2 | 3.8 | 42.2 | 35.7 | 0.2 | 1.6 | 1.1 | 3.8 | 1.6 | 1.23 |
| Mean | 44.0 | 51.73 | 11.63 | 0.13 | 3.60 | 41.77 | 35.13 | 0.17 | 1.53 | 1.03 | 3.57 | 1.50 | 1.190 |
| Sudan (n=8) | | | | | | | | | | | | | |
| Minimum | 39 | 50.6 | 11.1 | 0.1 | 3.9 | 41.5 | 32.0 | 0.2 | 1.6 | 1.0 | 3.2 | 1.2 | 1.23 |
| Maximum | 45 | 56.8 | 12.0 | 0.2 | 4.8 | 44.1 | 33.8 | 0.3 | 1.8 | 1.1 | 4.0 | 1.6 | 1.38 |
| Mean | 40.5 | 53.23 | 11.53 | 0.11 | 4.31 | 42.91 | 33.09 | 0.23 | 1.69 | 1.05 | 3.68 | 1.44 | 1.299 |

**TABLE I (continued)**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South Africa (n=5) | | | | | | | | | | | | |
| Minimum | 40 | 52.5 | 10.7 | 0.1 | 4.1 | 42.4 | 32.4 | 0.1 | 1.7 | 0.9 | 3.2 | 1.2 | 1.23 |
| Maximum | 47 | 58.6 | 11.2 | 0.1 | 5.1 | 44.4 | 34.4 | 0.3 | 1.9 | 1.1 | 3.8 | 1.4 | 1.37 |
| Mean | 43.4 | 55.90 | 10.96 | 0.10 | 4.48 | 43.48 | 33.18 | 0.22 | 1.82 | 0.98 | 3.50 | 1.32 | 1.312 |
| Australia (n=2) | | | | | | | | | | | | | |
| Minimum | 37 | 48.7 | 11.1 | 0.1 | 3.5 | 39.3 | 36.4 | 0.1 | 1.7 | 1.1 | 4.1 | 1.8 | 1.06 |
| Maximum | 41 | 51.3 | 11.2 | 0.1 | 3.7 | 39.3 | 37.2 | 0.2 | 2.0 | 1.2 | 4.2 | 1.8 | 1.08 |
| Mean | 39.0 | 50.00 | 11.15 | 0.10 | 3.60 | 39.30 | 36.80 | 0.15 | 1.85 | 1.15 | 4.15 | 1.80 | 1.070 |
| 8 countries (n=37) | | | | | | | | | | | | | |
| Minimum | 32 | 46.9 | 9.8 | 0.1 | 3.0 | 36.4 | 30.2 | 0.1 | 1.4 | 0.8 | 3.2 | 1.2 | 0.90 |
| Maximum | 51 | 58.6 | 13.7 | 0.2 | 5.1 | 44.8 | 40.3 | 0.3 | 2.1 | 1.4 | 4.4 | 1.9 | 1.48 |
| Mean | 41.2 | 51.77 | 11.43 | 0.11 | 3.96 | 41.51 | 34.86 | 0.20 | 1.71 | 1.08 | 3.66 | 1.52 | 1.202 |
| Diff. among countries | ** | ** | ** | n.s. | ** | ** | ** | n.s. | n.s. | ** | ** | ** | ** |
| Diff. among types | ** | n.s. | ** | n.s. | ** | ** | ** | n.s. | ** | ** | ** | ** | ** |

[a]n.s. = not significant. * = significant at the 5% level. ** = significant at the 1% level.

carrier gas was nitrogen at a flow rate of 40 ml/min. Compound retention times and areas were recorded automatically, and the results were calculated by means of a Shimadzu Chromatopac C-R2A. Standard methyl ester fatty acid mixtures were separated under identical conditions to identify the compounds. Moisture content was determined by heating the crushed samples for 2 h at 130 C, and oil contents were reported on a dry basis of seed without skin.

## RESULTS AND DISCUSSION

The 100-seed-weight, oil content, fatty acid composition and oleic acid content/linoleic acid content ratio (O/L ratio) of the Virginia, Runner and Spanish market types are shown as minimum, maximum and mean values in Table I. Analysis of variance among the countries and also types for 100-seed-weight, oil and fatty acid contents and O/L ratio have been carried out. The results of significant differences by F value also are shown in the table.

For the Virginia market type, there were significant differences in stearic, eicosenoic and lignoceric acid contents among the countries. The samples from China were the highest in stearic acid and the lowest in eicosenoic acid and lignoceric acid and differed significantly from the fatty acid compositions of samples from the U.S.A. and Australia by L.S.D. (5%).

The Runner market type was smaller than the Virginia market type in 100-seed-weight, whereas the types showed a similar fatty acid composition. No significant difference was observed between these types from U.S.A. in oil and fatty acid contents. The samples of Runner market type in this study are the variety Florunner which was derived from intraspecific cross between Virginia and Spanish botanical types. Florunner, therefore, might inherit its fatty acid composition from Virginia botanical type.

For the Spanish market type, there were significant differences in 100-seed-weight, oil content, palmitic, stearic, oleic, linoleic, eicosenoic, behenic and lignoceric acid contents, and O/L ratio among the countries. The main differences among the countries by L.S.D. (5%) are as follows. As to the oil content, the samples from South Africa showed the highest mean value (55.90%) and significant differences from those from other countries. On the other hand, the samples from Argentina showed the lowest mean value (47.86%) and significant differences from those from other countries except Thailand and Australia. Main fatty acid mean values ranged from 10.94% (China) to 12.96% (Paraguay) in palmitic acid, 38.04% (China) to 44.16% (Paraguay) in oleic acid, and 31.42% (Paraguay) to 38.43% (China) in linoleic acid. The samples from China showed significant differences from those from other countries except Australia in oleic and linoleic acid contents. The samples from Paraguay showed significant differences from those from other countries except South Africa in oleic acid content and from those from all other countries in linoleic acid content. The samples from Sudan differed significantly from those from other countries, except Brazil and South Africa, in oleic acid content and, except South Africa, in linoleic acid content. The range of O/L mean ratio was 0.990 (China) to 1.406 (Paraguay). Significant differences of O/L mean ratio among the countries were observed except Australia with China, Thailand, and Argentina; Brazil with Thailand and Argentina; Thailand with Argentina, and Sudan with South Africa. In general, the oil of peanuts contains more oleic acid than linoleic acid. Four samples of Spanish market type peanuts from China, however, showed higher linoleic acid content. On the field experiment in Japan, Miura et al. (9) reported O/L mean ratio: 0.95 in 12 varieties of Spanish botanical type. Taira

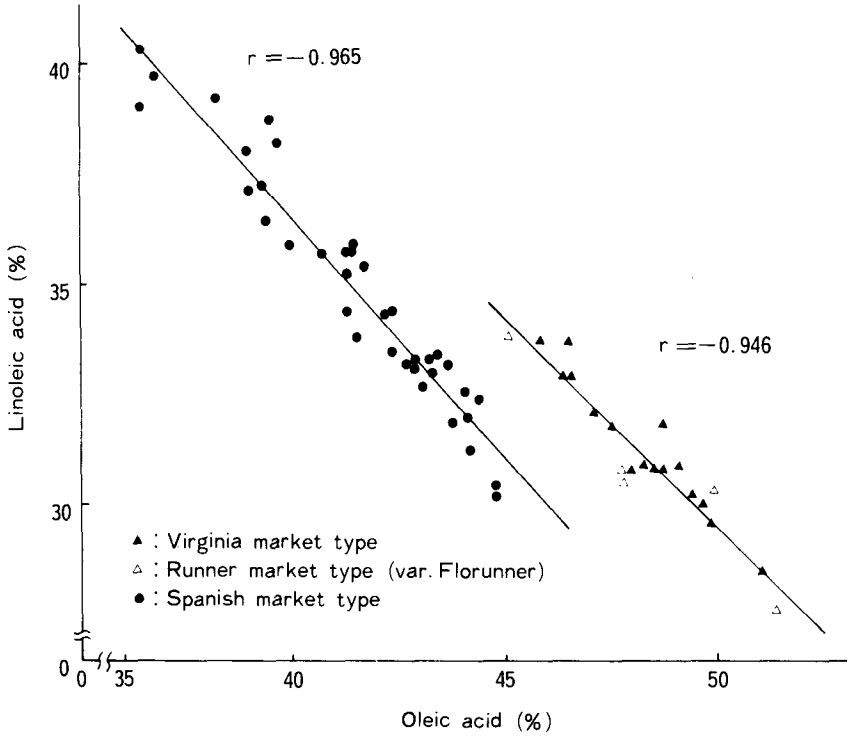


**FIG. 1. Relationship between oleic acid and linoleic acid contents of three market types of peanuts.**

(6) observed that two varieties of Japanese Virginia market type by intraspecific crossing between Virginia and Spanish botanical types showed a fatty acid pattern similar to the Spanish botanical type, and the fatty acid mean values of the varieties in three prefectures of north to south of Japan were 36.10%, 38.70%, and 40.90% in oleic acid and 43.80%, 40.25%, and 37.00% in linoleic acid, i.e. O/L ratio: 0.82, 0.96, and 1.11, respectively; that the daily mean temperature during ripening correlated negatively with linoleic acid content, and that there was significant negative correlation between both fatty acid contents. From the results, it was suggested that the low O/L ratio of samples from China may be affected by the low ripening temperature rather than by variety because they were grown farther north than the other samples. The high O/L ratio of Paraguay may be due to the high ripening temperature.

For the gross sample, there were significant differences in 100-seed-weight, palmitic, stearic, oleic, linoleic, arachidic, eicosenoic, behenic and lignoceric acid contents, and O/L ratio among the types. The Spanish market type, compared with the Virginia market type, was significantly higher in palmitic, stearic, linoleic, arachidic and behenic acid contents and lower in oleic, eicosenoic and lignoceric acid contents by L.S.D. (5%). In regard to the differences between Virginia and Spanish market types in the same country, the Spanish market type was significantly higher in palmitic, linoleic and behenic acid contents and lower in oleic acid content in China and Australia; higher in stearic acid content and lower in eicosenoic acid content in Australia, and higher in arachidic acid content in China.

As to the relationship between fatty acid contents, the correlation coefficients between oleic acid and linoleic acid were highest in both Virginia and Spanish market types. Worthington and Hammons (10) and Brown et al. (4) reported a high correlation between the fatty acid contents in one group of peanuts containing three types. Figure 1 shows the relationship between the fatty acid contents of three types. The scatter diagram could be divided into Virginia and Runner market type group (r=−0.946**) and Spanish market type group (r=−0.965**). In the case of the same linoleic acid content among the types, it was shown that the Spanish market type, compared with the Virginia and Runner market types, had a lower oleic acid content or O/L ratio.

ACKNOWLEDGMENT

A. Takizawa, Agricultural Production Bureau, Ministry of Agriculture, Forestry and Fisheries, Japan and Y. Matsuda, Public Health Research Institute of Kobe City provided the peanut samples.

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[Received October 24, 1984]