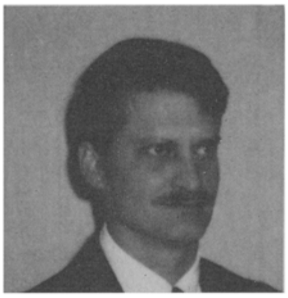

Peanut Oil

J.L. AYRES, Gold Kist Inc., 244 Perimeter Center Parkway, NE, Atlanta, GA 30346

ABSTRACT

Conventional expeller and expeller/solvent extraction processes for peanuts are compared to the nonconventional processes of direct solvent extraction, cold pressing and nonhexane solvent processes. Peanut composition, cleaning and specific extraction procedures have a major impact on finished crude oil composition, refining characteristics, final oil and meal quality and utility. Special care in raw material and process selection must be taken when using crude peanut oil for direct edible or biofuel applications. Changes in world oil prices and protein market, US peanut quota and price support program and plant breeding will have a major impact on peanut oil availability and prices in the future.

INTRODUCTION

Until recently, most of the attention on peanut crushing has dealt with oil recovery, with little concern for meal byproducts (1). With increased attention to peanut flour as a source of supplementary protein for human diets (2,3), the industry is taking a careful look at the effects of pre- and post-oil removal conditions on meal characteristics. Recovery of usable edible meals will have an impact on the method of oil extraction in the future. Energy and solvent costs have also forced the oil crusher to look at alternative methods of processing.

EXPELLER PROCESSES

Precleaning of shelled peanuts is critical to keep wear factors to a minimum (4,5). Improper dehulling will cause poor destoning of kernels, so if additional fiber is desirable to provide higher friction in the expeller, coarse ground hulls can be added to the kernels before cooking. Kernels should be broken into up to eight pieces using a hammer mill or bar cracking machine before cooking. A stack cooker is used to heat and moisture-condition peanuts prior to expelling. For straight expeller meal, a low moisture cook, with moisture of 3.5-4.5% and temperature of 115 C going to the expeller, is desirable for efficient operation (4). Higher moisture content is used for prepress/solvent processes (1,4) which produces a slightly softer cake which can be broken and flaked for extraction. Care must be taken to work oil foots back through the expellers on a low and consistent basis to prevent "buttering" and loss of caking in the expellers. Recent work (6) showed that an Ozawa ring-cage screw press could be used to press uncooked peanuts. Continous operation of this crushing technique needs to be tested. If low aflatoxin meal is required for edible meal production, peanut kernels must first be blanched (skins removed) and be electronically sorted to remove mold-damaged kernels. Expeller crushing of blanched peanuts is difficult, due to low moisture of dry blanched peanuts, 4.0-5.0% moisture, and low fiber, 1.7-1.9%, due to skin removal (7).

For hexane extraction, the expeller cake, containing 8-12% oil, is conditioned to 10% moisture, flaked and extracted using either an immersion or percolation extractor (8). Flake characteristics are more critical for percolation extraction. Immersion extractors give excellent oil recovery but miscella filtration is usually required. The resulting miscella filter cake must be returned to the meal desolventizer, which can cause excessive hexane losses unless the system is properly designed to handle these fines. After hexane recovery and oil stripping, the solvent extracted oil is added to the filtered expeller oil and held for shipment and refining.

Direct Hexane Extraction

Several processes have been described for direct extraction of peanuts (9-12). Work by Fan et al. (9), showed that peanut slices followed regular diffusion theory of Fick's law, as expected, extraction rates being much faster at low moisture levels in the slices. Work by Steele et al. (10), showed that when peanuts were wet heat conditioned to 6-12%, flaked and flakes dried, sufficient flake strength was maintained to use percolation extraction and still obtain good miscella clarity. Work by Pominski et al. (11), showed that moistening peanuts to 12% moisture, heating for 30 min to 82 C, drying to 6% moisture and flaking resulted in a flake with sufficient strength to be extracted with solvent. Direct extraction of peanuts not only eliminates the need for expellers but also allows milder heat conditions than conventional cooking which maintains nutritional and functional characteristics of edible meals. Since oil is recovered from solvent using conventional processes, there is very little difference between refining characteristics of conventional prepress/solvent extracted oil and direct extracted oil.

Cold pressed oil (13) has very little peanut flavor and shows less storage stability than corresponding solvent extracted oil (14). This difference may be due to the degree of removal of minor lipid components.

Aqueous Extracted Peanuts

Rhee et al. (15), devised a process which recovered oil from a dispersion of finely chopped peanuts in water. The process requires no flammable solvent and can be used to remove undesirable raw material components (i.e., aflatoxin). However, this method is less efficient than hexane extraction and demulsification is required to recover clear oils when emulsions are formed (16).

Other Solvents for Extraction

A recent review discusses alternatives to hexane extraction of vegetable oils (17). Alcohol solvents have the advantage of removing most of the aflatoxin from meals, but meals are difficult to desolventize and may have undesirable odors remaining in them. Ketone solvents also will remove aflatoxin but extracted meals have an unusual odor on storage. Other liquid solvents have been used (i.e., aldehyde, ethers, esters and chloro/fluorocarbon types) but these have safety, toxicity and food safety related problems.

Supercritical fluids such as carbon dioxide have been tested on various oilseed products (18). The solvent is easily removed from meal and oil, is nonflammable and extracts higher quality oil, but commercial feasibility against more conventional solvents is still to be determined for oilseed extraction (17,18).

OIL COMPOSITION

The fatty acid composition of peanut oil varies considerably by peanut maturity, genotype and growth location.

Table I shows the ranges of composition of peanut oil tentatively adapted by the Food and Agriculture Organization/ Codex Alimentarius Committee on Fats and Oils (19), as well as the ranges of oil composition for 82 diverse genotypes of peanuts examined over a 3-year period (20). Subsequent work by Worthington (21) showed the linolenic acid content of eight peanut cultivars grown at four locations ranged from 0.03 to 0.13 weight percent of total fatty acid. This low level of linolenic acid is one of the reasons for the excellent flavor stability of peanut oil.

TABLE I

Fatty Acid Composition of Peanut Oil

Fatty acid	Weight percent (19)	Weight percent (20)
<14	<0.1	–
14:0	<0.1	–
16:0	6.0-15.5	7.4-12.9
16:1	<1.0	–
18:0	1.3-6.5	1.6-5.3
18:1	36-72	35.7-68.5
18:2	13-45	14.0-40.3
18:3	<1.0	–
20:0	1.0-2.5	0.9-2.2
20:1	0.5-2.1	0.6-2.0
22:0	1.5-4.8	1.3-5.1
22:1	<0.1	–
24:0	1.0-2.5	0.6-2.0

As Florunner variety peanuts mature from the flattened and white immature stage to full maturity, oil content increases from 25 to 48% (dry weight basis) and triacylglycerol content increases from 85 to 96% in the oil (22). During this same maturity period, the free fatty acids decrease from 4.5% to 0.7% and diacylglycerides drop from 2.4 to 0.5%. During changes in maturity, there was a general increase in 18:1 and a slight drop in most other fatty acids with a more pronounced drop in C22:0 (23).

The structure of the oil triglycerides is similar to other seed oils with saturated fatty acids, C16:0, 18:0, 20:0, 22:0 and 24:0 almost totally incorporated in the *sn*-1- and *sn*-3-position (24). Oleic acid is equally distributed in all three positions and linoleic acid is more disproportionately in the 2-position. According to Hokes and Worthington (24), oleic and linoleic acid constitute 97% of the fatty acid in the 2-position of the triglycerides. Work on African peanut oil (25) confirmed earlier studies indicating a low concentration of saturated fatty acids in the 2-position.

Free fatty acids (FFA) are not only a function of peanut maturity, but also of the degree of damage to the kernels. Sound mature peanuts will generally have an FFA content of less than 0.5%. Most of the US peanut oil will have from 0.5-1.5%, but on occasions, levels up to 5% are encountered if the peanuts are high in mold damage and/or very immature kernels.

Peanut oil contains about 0.3-0.4% phospholipid consisting mainly of phosphatidyl ethanolamines, phosphotidylcholine, phosphatidylinositol and phosphatidic acid (26). Phospholipid fatty acids are higher in palmitic acid than in corresponding triglycerides.

The unsaponifiable fraction of peanut oil includes 0.15-0.90% hydrocarbon sterol esters and 0.59-1.22% free sterols (22). The oil also contains tocopherols and plant pigments. Carpenter (27) found a considerable level of tocopherols in refined peanut oil with a total tocopherol content of 53 mg/100 g and most as α- or γ-tocopherol.

OIL REFINING

Peanut oil is generally alkali refined, bleached and deodorized to obtain salad or cooking oil. If expeller oil and miscella from hexane extracted oil has been properly filtered to remove meal fines, the small quantity of phospholipids (0.3-0.4%) do not represent a major shipping or refining problem. Due to the low content of FFA in peanut oil, it is doubtful that steam refining would be useful (28). Alkali refining and bleaching eliminates aflatoxin in refined oils (29).

As discussed earlier, prepress hexane extracted oils and direct hexane extracted oils have similar refining characteristics. Extraction with other solvents will have a bearing on refining characteristics. Alcohol solvents solubilize more phosphatides, carbohydrates and alcohol soluble proteins than hexane (17) which could give rise to problems in refining. Ketone solvents do not extract appreciable quantities of phospholipids so lower refining losses would be expected. Supercritical carbon dioxide extraction results in a lower content of FFA in the oil which would reduce refining loss.

Although refined peanut oil is an excellent cooking oil, it cannot be winterized easily, due to difficulty in separating crystals from oil after cooking (30). This limits the use of peanut oil in refrigerated salad oil.

Unrefined Uses

Crude peanut oil is used in a large number of oriental households and in Hong Kong it is used in over 90% of the local Chinese households (31). The use of crude oil from peanuts containing high aflatoxin indicates a potential health hazard (31). However, if peanuts are blanched and electronically sorted to remove damaged or defective kernels, oil free of aflatoxins can be produced using conventional processing (7). Crude oil, when heated, will discolor unless degummed, and foams due to residual free fatty acids. Although crude peanut oils have excellent, peanut-like flavor, the excessive foaming will cause considerable problems in continuous frying operations.

Crude peanut oil can be used as a substitute for diesel oil for farm use. Figures from a 5-year average show that 21 million BTU/acre can be produced from Georgia farm acreage in oil alone. When total yield of meal (as feed), hulls and vines are converted to energy, the output energy is almost four times the energy input (31). Capital costs, storage, effects on engine wear are yet to be completely studied, but this potential use may hold promise in the future.

Work is currently underway in the USA in an attempt to increase oil content in peanuts for both edible and fuel usage (31). Since oil content and yield/acre are rather complexly related, considerable time may be required before higher oil yield per acre can be realized. Work on white-skinned peanuts was originally designed to allow rapid identification of oil stock peanuts in the US acreage allotment program. However, these white-skin peanuts might allow rapid removal of aflatoxin contaminated peanuts without blanching. Production of higher value peanut meal at a lower cost would in turn stimulate greater production of peanut oil.

Oil and Meal Market

With the current low oil and meal market in the world and US peanut support price system, expansion of peanut crushing in the USA is unlikely in the near future. Only if we can find higher yielding varieties, higher prices for peanut meal or flours or reduce the costs for crushing can we expect expansion in peanut production or peanut oil production.

REFERENCES

1. Ayres, J.L., L.L. Branscomb and G.M. Rogers, JAOCS 51:133 (1974).
2. Altschul, A.M., Proteins: Their Chemistry and Politics, Basic Books, New York, NY, 1965, p. 292.
3. Woodroof, J.G., Peanuts: Production, Processing and Products, 2nd edn., Avi Publishing, Westport, CT, 1973, chap. 11.
4. Ward, J.A., JAOCS 53:261 (1976).
5. Garcia M., E.J., Ibid. 53:259 (1976).
6. Johnson, L.A., Peanut Sci. 7:38 (1980).
7. Ayres, J.L., and B.L. Davenport, JAOCS 54:109A (1977).
8. Stein, W., and F.W. Glaser, Ibid. 53:283 (1976).
9. Fan, H.P., J.C. Morris and H. Wakeman, Ind. Eng. Chem. 40:195 (1948).
10. Steele, B.C., D.R. Barr, C.T. Hunt and J.L. Ayres, U.S. Patent 4,008,210 (1977).
11. Pominski, J., H.M. Pearce, Jr., and J.J. Spadaro, Proc. Am. Peanut Research Ed. Assoc., Inc. 9:64 (1977).
12. Annual Progress Report for the Natural Fibers and Food Protein Commission, Texas Eng. Exp. Station, TX, 1977.
13. Pominski, J., H.M. Pearce, Jr., and J.J. Spadaro, Food Technol. 24:92 (1970).
14. Brown, D.F., C.M. Cater and K.F. Mattil, Proc. Am. Peanut Research Ed. Assoc., Inc. 5:202 (1973).
15. Rhee, K.C., C.M. Cater and K.F. Mattil, J. Food Sci. 37:90 (1972).
16. Lawhon, J.T., L.J. Manak, K.C. Rhee and E.W. Lusas, Ibid. 46:391 (1981).
17. Hron, R.J., Sr., S.P. Koltun and A.V. Graci, Jr., JAOCS 59: 674A (1982).
18. Mangold, H.K., Ibid. 59:673A (1982).
19. Spencer, G.F., S.F. Herb and P.J. Gormisky, Ibid. 53:94 (1976).
20. Worthington, R.E., R.O. Hammons and J.R. Allison, J. Agric. Food Chem. 20:727 (1972).
21. Worthington, R.E., JAOCS 54:167 (1977).
22. Sanders, T.H., Ibid. 57:8 (1980).
23. Sanders, T.H., Ibid. 57:12 (1980).
24. Hokes, J.C., and R.E. Worthington, Ibid. 56:953 (1979).
25. Sempore, G., and J. Bezard, Ibid. 59:124 (1982).
26. Singleton, J.A., and H.E. Pattee, Ibid. 58:873 (1981).
27. Carpenter, A.P., Jr., Ibid. 56:668 (1979).
28. Sullivan, F.E., Ibid. 53:358 (1976).
29. Parker, W.A., and D. Melnick, Ibid. 43:635 (1966).
30. Mattil, K.F., F.A. Norris, A.J. Stirton and D. Swern, Bailey's Industrial Oil and Fat Products, 3rd edn., Interscience Publishers, New York, NY, 1964, p. 1007.
31. Hammons, R.O., Proc. Am. Peanut Research and Ed. Assoc. 13:12 (1981).