Mini-Review:

What about the Allergenicity of Vegetable Oils?

S. Frémont, Y. Errahali, M. Bignol, I. Montagnon, M. Metche, J.P. Nicolas

Laboratory of Medical and Pediatric Biochemistry, Faculty of Medicine, University Nancy I, France

SUMMARY

Cases of allergy to peanut, sunflower seed, soybean and sesame seed oils have been reported in the literature, although some authors have claimed that these oils are not allergenic.
The aim of this article is to review this subject, to describe the processing methods to which the seeds are subjected during the extraction of their oil, to recall that oils do not consist solely of triglycerides and to describe the findings of our studies.
The allergenicity of oils is a frequent subject of controversy and the bibliography constantly produces contradictory examples. This can be explained by the variability of the processes used in industry, and by the conditions under which proteins are extracted in the laboratory.
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KEYWORDS

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Sophie Frémont

Correspondence:
Dr. S. Frémont
Laboratory of Medical and Pediatric Biochemistry, Faculty of Medecine,
University Nancy I, Avenue de la Forêt de Haye, 54505 Vandoeuvre Cédex, France
Phone: +33 (0) 3 83 68 33 32
Fax: +33(0)3 83 68 33 29
eMail: fremont@lbmp.u-nancy.fr

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INTRODUCTION

Soy oil is the vegetable oil consumed in the largest amounts worldwide (29%). In France, sunflower (40%) and oil-seed rape (26%) oils are the ones most commonly used, those of soy and peanut oils each corresponding to less than 5% of total consumption (Proléa-Documentation 1998, ONIDOL, Paris, France) (Table 1).
Vegetable oils are produced from the corresponding seeds after mechanical processing: shelling, flaking, in some cases cooking, pressing and possibly hexane-extraction. The crude oil that is obtained after these steps contains high levels of triglycerides, but also contains partial glycerides, free fatty acids, phospholipids, coloring agents, free sugars, glycolipids, waxes, metals, water …. and may also contain traces of proteins. Some toxic substances such as gossypol, a brown polyphenolic compound of cotton oil, may be naturally present in certain oils. Moreover organophosphorus or organochloride pesticides, liposoluble substances often present on the top of the seeds, can be found in vegetable oils.

The purpose of refining is to produce a product that is neutral in flavor, attractive in appearance and devoid of unwanted substances. Each of the steps in the chemical refining process is carried out under specific conditions defined by each manufacturer. Briefly, demucilagination corresponds to the treatment of the oil by phosphoric acid, to allow the elimination of phospholipids, glycolipids and gum. This step is followed by neutralisation using sodium hydroxide, to eliminate free fatty acids. Washing steps using water clear oil of vegetable wax, residual phospholipids and soap. After drying, the bleaching step conducted by adsorption on bleaching clay eliminates mainly pigments that have been partially destroyed by neutralization. At a low temperature, vegetable waxes are insolubles. It is possible to eliminate them by filtration or centrifugation. The last step is to get rid of odors and peroxides at a very high temperature under vacuum. An example of the refining process of sunflower oil is given in Table 2.

SPECIFIC VEGETABLE OILS

An overview of the studies conducted on peanut, sunflower, soy and sesame oil is given in Table 3.

Peanut oil

The high incidence of peanut allergy has led to investigations of peanut oil (Moneret-Vautrin 1998). In 1981 and 1997, Taylor et al. and Hourihane et al. respectively concluded that refined peanut oil was not allergenic to peanut-sensitive individuals, but in 1991 the team of Moneret-Vautrin reported two cases of allergy to peanut oil in infants fed with milk formulas. Immunochemical studies have identified allergens in cold-pressed crude oils (Hoffman & Collins-Williams 1994), in oils that have been refined at temperatures between 50 and 150°C (14 to 80 kDa) (Teuber et al. 1997), and in one oil processed at high temperature (18 kDa) (Olszewski et al. 1998).

Table 1: Consumption of vegetable oils in France and throughout the world (ONIDOL 1998)

Oil	World	France
Soybean	29%	5%
Palm	21%	9%
Oil-seed rape	15%	26%
Sunflower seed	11%	40%
Cotton seed	5%	-
Peanut	5%	4%
Sesame seed	0.7%	?

Table 2: Description of the steps of refining process of sunflower oil (from Zitouni et al. 2000)

Step	Oil obtained	Treatment used	Temperature applied	Time	Removed components
0-Expeller and chemical extraction	Crude oil (A)				
1-Acidic and neutral treatment	Neutralized oil (B)	H_3PO_4 / NaOH	85 °C	15 min	phospholipids, free fatty acids, metals, pigments, products from oxidation, some contaminants
2-Pregumming by centrifugation	Pre-gummed oil (C)	Soap and water	10 °C	4 h	Plant wax
3-Washings	Washed oil (D)	Water	85°C	few minutes	Soap, phospholipids
4-Bleaching	Bleached oil (E)	Filters	85	20 min	Pigments, residues of soap, phospholipids, metals, products from oxidation
5-Gumming by filtration	Gummed oil (F)	Filters	10 °C	5 h	Plant wax
6-Deodorization	Refined oil (G)	Water steam	220°C-4 min under vacuum	2h30min	Peroxides, odors, some contaminants

Sunflower oil

There have been numerous studies of sunflower seeds. Noyes et al. (1979), Halsey et al. (1986), Iwaya et al. (1994) and Axelsson et al. (1994) have reported reactions such as generalized urticaria, dyspnea and anaphylactic shock after consumption of sunflower seed. Klurfeld & Kritchevsky (1987) and Halsey et al. (1986) extracted proteins from refined oil and virgin cold-pressed oil, and concluded that these oils were entirely safe. In 1994, Kanny et al. reported two episodes of anaphylactic shock in a female patient, occurring at an interval of two months, after she had eaten a meal containing sunflower oil and margarine. Skin tests and a positive oral challenge test with 5 ml of sunflower oil, demonstrated that the anaphylactic shock had been induced by sunflower oil. Our team identified proteins both in the crude oil (13.6 µg/mL) and after it had been refined by heat treatment (0.22 µg/mL) (Figure 1). One of these proteins (67 kDa) found in the refined oil was recognized by the serum IgE of the patient allergic to the oil (Figure 2) (Zitouni et al. 2000).

Table 3: Overview of the studies conducted on peanut, sunflower, soy and sesame oil

Seeds	Oil Type	Proteins		Allergenicity		References
		Concentration (µg/mL of oil)	Molecular Mass (kDa)	In vitro	In vivo	
Peanut	Refined	no protein				Tattrie et al. 1973
Peanut	Unspecified				Negative skin tests, negative DBPCFC (0/10)	Taylor et al. 1981
Peanut	Unspecified				Positive oral provocation test (2/2)	Moneret-Vautrin et al. 1991
Peanut	Cold-pressed Hot-pressed	0.2-3.3 in some cold-pressed oil		Dot blots : positive for some cold-pressed oil, negative for hot-pressed oils (pooled sera)		Hoffman et al. 1994
Peanut	Virgin peanut oil				Positive skin-prick tests (1/1), labial challenge (2/2) and SBOC (4/4)	Moneret-Vautrin et al. 1994
Peanut	Crude and refined peanut oil				Negative DBPCFC with refined oil, positive with crude oil (10/60)	Hourihane et al. 1997
Peanut	a) Unrefined b) Refined, bleached and deodorized	a) 10.5-10.7 b) 3.0-5.7		Slot Blot : strong IgE binding for unrefined oils, low or no IgE binding for refined oils, Western-Blot: same binding pattern for peanut extract and unrifined peanut oil extract		Teuber et al. 1997
Peanut	a) Crude b) Neutralized c) Refined	a) 3.4 µg/g b) 0.2 µg/g c) 0.1-0.2 µg/g	14-76	LHR positive with the protein extract (9/11) Western-Blot revealed a 18 kDa protein	Positive DBPCFC (4/11) Skin-prick tests negative with refined peanut oil, positive with protein extract from crude and refined oil (5/7)	Olszewski et al. 1998
Peanut	a) Peanut oil extract b) Peanut oil proteinic extract				a) Positive DBPCFC (14/62) b) Positive skin-prick tests (9/10)	Moneret-Vautrin et al. 1998
Sunflower	Cold-pressed and refined	2 to 8			Negative SPT (2/2), Negative DBPCFC (2/2)	Halsey et al. 1986
Sunflower	Refined	0.85				Klurfeld et al. 1987
Sunflower	Unspecified				Positive scratchs test (1/1)	Frazier et al. 1995

Sunflower	a) Crude b) Neutralised c) Pregummed d) Washed e) Bleached f) Gummed g) Refined	a) 13.6 b) 11.5 c) 11.3 d) 2.7 e) 1.6 f) 1.4 g) 0.22	a) 67-145 b) 67-145 c) 67-132 d) 67-132 e) 67-132 f) 67 g) 67	67 kDa (Western-Blot)	Positive SPT (1/1) Positive DBPCFC (1/1)	Zitouni et al. 2000
Soybean	Refined	no protein				Tattrie et al. 1973
Soybean	Refined and cold pressed			Non allergenic proteins	Negative DBPCFC (7/7)	Bush et al. 1985
Soybean	Unspecified	110-3300				Porras et al. 1985
Soybean	a) Crude b) Refined	a) 1.9 b) 0.72				Klurfeld et al. 1987
Soybean	Oxidized soy oil			Positive ELISA	Proteins interacted with oxidized soy oil are allergenic to soybean-sensitive patients	Doke et al. 1989
Soybean	Soy oil emulsion (parenteral nutrition)				Anaphylactic shock (1/1)	Andersen et al. 1993
Soybean	Refined	0.01-0.04	58-67	Non allergenic proteins		Awazuhara et al. 1998
Soybean	a) Unrefined b) Refined	a) 0.09-0.14 b) 0.035	a) 14-94 b) 14-94	a) 53, 57 kDa Positive EAST inhibition b) Non allergenic proteins		Paschke et al. 2001
Soybean	a) Crude b) Deodorized	a) 1.8 b) 0.3	a) 14-150 b) 14-150	56-57 kDa Positive RAST		Errahali et al. 2002
Soybean	Soy oil emulsion				Positive patch test (1/1) and positive oral challenge (1/1)	Moneret-Vautrin et al. 2002
Sesame	Unspecified			Positive RAST, positive BHR (1/1)	Positive skin-prick test (1/1)	Chiu et al. 1991
Sesame	Unspecified			LHR positive in 1/3 case	Positive oral provocation test (1/2) Positive labial provocation test (2/2)	Kanny et al. 1996

LHR leucocyte histamine release, BHR basophile histamine release, SBOC single blind oral challenge

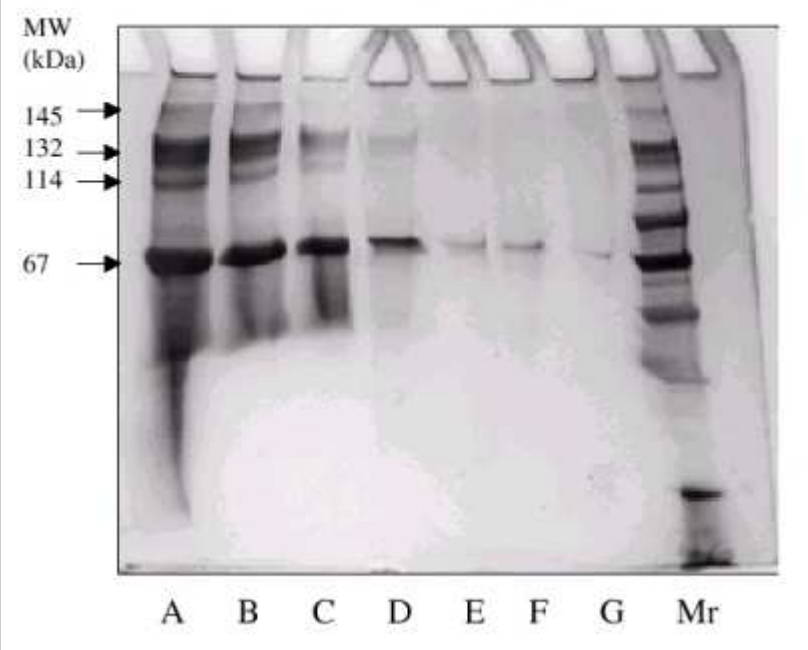

Figure 1: SDS-PAGE of protein extracts from samples of sunflower oil taken at different steps during refining (from Zitouni et al. 2000) A: Crude oil , B: Acidification and neutralisation, C: Pregumming, D: Washing, E: Bleaching, F: Gumming, G: Deodorizing

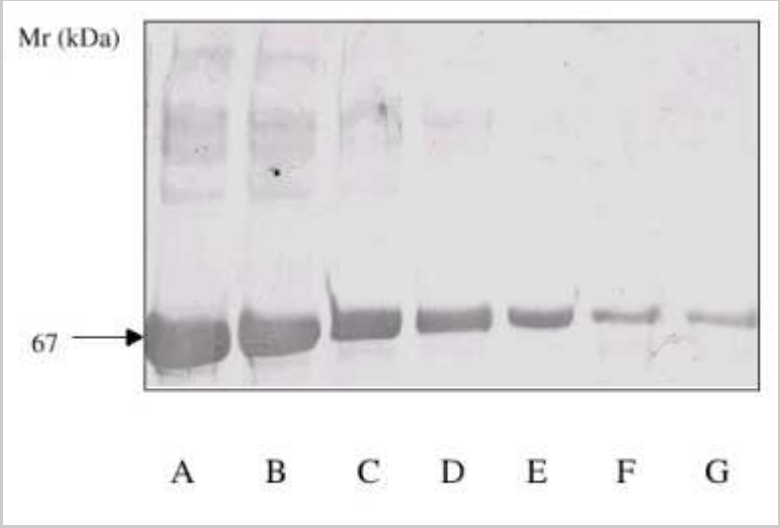

Figure 2: Western blot of protein extracts from samples of sunflower oil taken at different steps during refining, using a serum from a female patient allergic to sunflower oil (from Zitouni et al. 2000) A: Crude oil , B: Acidification and neutralisation, C: Pregumming, D: Washing, E: Bleaching, F: Gumming, G: Deodorizing

Soybean Oil

Soybean allergy is considered as one of the five most common causes of food allergy among children. The prevalence of soybean allergy has been estimated at 1% among adults. Allergy to soy oil is therefore a crucial matter which demands investigation (Paschke et al. 2001).
In 1985, Bush et al. concluded that refined soy oil was not allergenic. Indeed the authors enrolled seven soybean-sensitive patients in a double-blind crossover study and no reactions were observed with the commercially available soybean oils. However, Awazuhara et al. (1998) demonstrated the presence of proteins in soy oil, and the presence of allergens in soy lecithin by in vitro methods (SDS-PAGE and immunoblotting of soy oil proteins performed with the sera from 15 soybean-sensitive patients). Our team's study of soy lecithins and egg lecithins confirmed the allergenicity of the proteins in these lecithins (Palm et al. 1999). In the case of soy lecithin, one patient had a negative prick test to soy lecithin and a positive double blind placebo controlled oral challenge at 100 mg of soy lecithin. Paschke et al. (2001) identified allergens in the unrefined oil, but not in the refined oil. More recently, our team has shown that the IgEs of the serum of soybean-sensitive patients specifically recognized 28 and 56 kDa proteins extracted from deodorized oil (Errahali et al. 2002).

Sesame Seed Oil

Sesame seed has been subjected to many clinical studies, but there has still been little attempt to characterize the allergens. From 1978 to 1991, Kägi & Wüthrich (1993) found only nine cases of allergy to sesame seed. However, the discovery in 1996 of 6 cases of allergy to seed and/or sesame oil underlines the growing risk of sesame consumption (Kanny et al. 1996).
Chiu & Haydik (1991) report one case of anaphylactic shock to sesame oil. Kanny et al. (1996) found that the histamine release assays were positive in 1/3 cases with sesame oil, the labial provocation test was positive in 2/2 and the oral provocation test was positive in 1/2 at a dose of 3 mL.
It should be noted first that sesame oil is supplied in unrefined form, and second that sesame oil is often a masked allergen, frequently labeled "vegetable oil" in a wide variety of products like margarine.

CONCLUSIONS

Food allergies to peanuts, sunflower, soybean and sesame seeds have been well established, although allergies to the oils of these seeds remain controversial. Various factors may account for this controversy:

- The process by which the oil is prepared. The oil can be obtained by mechanical pressing, or by an extraction process involving a solvent. It may be submitted to refining, under conditions that are chosen and developed by each manufacturer. These refining conditions are crucial, and may influence the concentration and denaturing of the proteins.
- The conditions under which the proteins are extracted from the oil in the laboratory. It is very difficult to extract amphiphilic molecules (proteins) from a hydrophobic medium (oil). As a result, the quantity and quality of the proteins extracted are directly determined by the extraction method used.
- The source of the allergenic proteins in the oil is not clear: they may be native proteins or may have been modified by the industrial process. The severity of the clinical reactions induced by the DBPCFC conducted using a few milliliters of oil (corresponding to a few micrograms of protein) suggest that an adjuvant effect may be involved.

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[Summary] [Abbreveations]

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