Technical

The Fatty Acid Composition of the Oil of the Winged Bean (*Psophocarpus tetragonolobus* L.) Seeds

T.E. EKPENYONG[1] and **R.L. BORCHERS**, Laboratory of Agricultural Biochemistry, University of Nebraska, Lincoln, NE 68583

ABSTRACT

The seeds of the winged bean, *Psophocarpus tetragonolobus* L. were found to be rich in oil. The oil was examined for its iodine value, saponification value and fatty acid composition by gas liquid chromatography. The value (area percent) for fatty acids as methyl esters were: 14:0 (0.2%); 16:0 (9.1%); 16:1 (0.4%); 18:0 (5.4%); 18:1 (41.0%); 18:2 (29.5%); 18:3 (1.9%); 20:0 (2.0%); 20:1 and 18:4 together (2.2%); 22:0 (7.3%) and 24:0 (1.0%). The iodine value (Wij solution) was 91. The oil contains an appreciable amount of unsaturated fatty acids, especially linoleic 18:2 (29.5%). The predominant saturated fatty acid is palmitic 16:0 (9.1%).

INTRODUCTION

The winged bean, *Psophocarpus tetragonolobus* L., is a little-known tropical legume. It is a source of dietary protein and edible oil (1-3). It has agricultural and nutritional potentials: the green pods, leaves and seeds are rich in proteins and vitamins. The tuberous roots are slightly sweet and contain as much as 20% protein on a dry weight basis (1). The plant produces many tubers and nodules (4-7); every part of it can be used in human and animal nutrition. Immature pods can be eaten raw; the young leaves are used as vegetables; and ripe seeds are used in the preparation of tempeh, a mold-fermented cake, often made with cooked soybean seeds (*Glycine max.*). Unlike soybean, all parts of the plant are edible—tubers, seeds, leaves, flowers and shoots—and it has no bitter, beany flavor as in soybean products. Because of the exceptional qualities of the winged bean, especially the possibility of using the ripe seed as a source of edible oil, this study was aimed at determining the fatty acid composition of winged bean seed oil.

MATERIALS AND METHODS

The seeds of the winged bean variety, TPt-2, were obtained from the International Institute of Tropical Agriculture, Ibadan, Nigeria. Fatty acid methyl esters used as standards were purchased from Sigma Chemical Company, St. Louis, MO; other reagents used were prepared according to AOAC methods (8).

Extraction of Oil and Analyses

The extraction procedure was a modified method (9). Beans (10g) were finely ground with a micromill, and 30 ml methanol-chloroform (2:1, v/v) was added; extraction in a Waring Blender followed for 2 min. The extract was filtered, reblended with a mixture of 30 ml of the methanol-chloroform and 7 ml water. The homogenate was filtered, and the residue was washed with 15 ml of extractant. A trace of butylated-hydroxy toluene (BHT) was added to prevent oxidation of fatty acids. To the combined filtrates were added 25 ml chloroform and 29 ml water. The mixture was shaken, and the phases were allowed to separate. A portion (25 ml) of the chloroform layer was taken, diluted in 25 ml benzene and concentrated in vacuo. The residual lipids were dissolved immediately in 2.5 ml chloroform and the solution was cleared by centrifugation.

Chemical analysis to determine the approximate chemical composition and iodine value was done as described by AOAC (8).

Preparation and Gas Liquid Chromatography of Methyl Esters

The preparation of methyl esters was done as described by Metcalfe et al. (10). The mixture of methyl esters was analyzed isothermally on 2.1 m x 6 mm (id) glass column packed with H.I.EFF 1,4-butanediol succinate polyester (Applied Science) on AW-DMCS Chromosorb W (80-100 mesh) using a Pye Series 104 gas chromatograph equipped with a flame ionization detector. Nitrogen (OFN) carrier gas was used at a flow rate of 50 ml/min. Gas chromatograph peaks were identified by comparison with pure standard methyl esters with respect to retention times by plotting the log of retention times against carbon number. The percentage of each ester was calculated as the percentage of the total area of all the peaks.

RESULTS AND DISCUSSION

The winged bean seed extraction yielded about 16% oil. The oil is a fine, clear, light-yellow fluid. The composition of the seeds is presented in Table I, whereas Table II presents the chemical composition of the different parts of the winged bean plant. Compared to other legumes, the winged bean is similar to soybean (*Glycine max.*) and African locust bean (*Parkia filicoidea*). The fiber content is about twice that of other legumes, except for cowpea (*Vigna unguiculata*).

The fatty acid composition and some characteristics of the oil extracted from winged bean seeds are shown in Table III. The three most common fatty acids of vegetable origin are palmitic (16:0), oleic (18:1) and linoleic (18:2). Winged bean seed oil contains an appreciable amount of unsaturated fatty acids, especially linoleic acid (18:2). Compared to soybean, it has a very low amount of linoleic acid (18:3), which contributes to its stability. Based on the percentages of the three most common fatty acids in oils of vegetable origin, winged bean seed oil resembles peanut oil. Both oils contain similar amounts of myristic, palmitic, stearic and lignoceric acids, which are saturated fatty acids. Both oils also contain more oleic than linoleic acid and relatively higher amounts of long chain saturated fatty acids than soybean oil.

[1]Present address: Department of Animal Science, University of Ibadan, Ibadan, Nigeria.

TABLE I

Chemical Composition of Mature Winged Bean Seeds (g/100 Edible Portion)[a]

Composition	Legumes				
	Winged bean	Soybean	Cowpea	Peanut[b]	African locust[c] bean
Moisture %	10.4	8.2	11.3	6.5	7.0
Fat g	15.8	16.1	1.7	44.8	19.5
Crude protein g	35.9	39.0	22.9	23.2	32.3
Carbohydrate g	23.9	25.4	50.6	23.0	37.1
Fiber g	9.2	4.7	8.5	2.9	4.1
Ash g	4.9	6.6	5.1	2.5	4.1
Calories	381.0	402.0	315.0	549.0	426.0

[a]From "Food Composition Table for Use in Africa" FAO/USDA/HEW, 1968.
[b]Peanut (groundnut) = *Archis hypogea.*
[c]African locust bean = *Parkia filicoidea* L.

TABLE II

Chemical Composition of the Different Parts of the Winged Bean Plant (g/100 g Edible Portion)

Composition	Plant part					
	Dry seeds	Unripe pods	Ripe pods	Stems leaves	Leaves	Roots
Moisture %	10.4	80.6	88.2	77.9	75.8	57.4
Fat	15.8	2.8	0.3	1.1	1.1	0.9
Protein	35.9	2.9	3.0	5.9	5.8	11.6
Carbohydrates	23.9	9.2	6.5	8.2	—	20.7
Fiber	9.4	2.4	1.2	5.0	—	7.4
Ash	4.9	2.1	0.8	1.9	2.3	2.0
Calories	381.0	73.6	40.7	66.3	33.0	137.0
Mineral (mg/100 g)						
Calcium	275	240	66	263	184	30
Phosphorus	310	53	29	52	73	45
Potassium	117	208	195	176	—	—
Iron	10	7	0.1	2	6	2
Sodium	35	3	3	—	—	—
Magnesium	178	—	—	—	8	—

TABLE III

Fatty Acid Composition of Winged Bean Seed Oil Compared with Soybean and Peanut Seed Oils[a]

Fatty Acid		Winged bean[a]	Winged bean[b]	Soybean[c]	Peanut[d]
Myristic	14.0	0.2	0.06	0.1	0.4
Palmitic	16.0	9.1	8.9-9.7	11.0	10.0
Palmitoleic	16.1	0.4	0.83	0.1	1.7
Stearic	18.0	5.4	5.7-5.9	4.0	4.0
Oleic	18.1	41.0	32.3-39.0	25.0	61.0
Linoleic	18.2	29.5	27.2-27.8	50.0	18.0
Linolenic	18.3	1.9	1.1-2.0	8.0	—
Arachidic	20.0	2.0	2.0	0.4	0.9
Eicosenoic	20.1	2.2	2.5	—	1.1
Behenic	22.0	7.3	13.4-15.5	0.3	2.5
Lignoceric	24.0	1.0	—	—	1.0
Iodine value		91		125-128	84-102
Saponification value				188-195	188-196
Total saturated		25	30	—	—
Total unsaturated		75	70	—	—
% Oil		16.3	16.7	—	—

[a]Research in progress.
[b]Cerny et al., 1971 (11).
[c,d]Hilditch and Williams, (13).

Winged bean oil contained about half as much behenic acid (22:0) as reported by Cerny et al. (11), and contains more behenic acid than is found in both soybean and peanut oils. Behenic acid is a long chain saturated fatty acid with 22 carbon atoms and a melting point of 80 C, and it is chemically related to erucic acid, having one double bond. The long-term nutritional effect of consuming oils containing erucic acid has puzzled experts for some time.

Despite the poor digestibility of behenic acid, its toxic effects were not observed when children were fed undefatted winged bean flour containing 160-180 mg of behenic acid/kg body weight/day (3). Behenic acid is found mainly in the unsaturated fraction which is lost during industrial refining of crude edible oil. The contents in arachidic, behenic and lignoceric acids in peanut oil were also found to be half that of arachidic and behenic acids together in winged bean seed oil.

Cerny (3) suspected the presence of an unusual fatty acid, tentatively identified as parinaric acid on the basis of relative retention times. Parinaric acid is found as a constituent of balsam (*Impatiens balsamina*) and edible drupes (*Parinarum laurinum*) (12). Parinaric acid apparently was not isolated before from edible legume seeds (13); it is unsuitable fo for use in human diet. Parinaric acid, a conjugated 18:4, would not coelute with 20:1. Further examination of this fraction using the method of plotting the log of retention times against carbon number showed conclusively, against earlier speculations (3), that the unusual fatty acid is eicosenoic acid. This disagrees with Cerny's tentative result (3), which identified this fraction as parinaric acid. Because parinaric acid is toxic, the acceptance of winged beans and their oil as foods was hindered. The presence of eicosenoic acid, however is in agreement with more recent research by others (14).

ACKNOWLEDGMENTS

Dr. Prabha Rawate assisted with fatty acid determinations and the Laboratory of Agricultural Biochemistry, UNL, provided financial support. Dr. Fred Opute of the University of Benin, Nigeria, assisted with the chemical identification of the fatty acids.

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[Received March 19, 1979]

Kinetics of Nickel Catalyst Poisoning

B. DROZDOWSKI and **M. ZAJAC**, Technical University of Gdańsk, Institute of Organic and Food Chemistry and Technology, Gdańsk, Poland

ABSTRACT

Hydrogenation was done in a "dead-end" type of reactor with automatic recording of hydrogen absorption. In order to determine the poisoning rates of various nickel catalysts with phospholipids, allyl isothiocyanate (AITC), free fatty acids, sodium soaps and products of lipid oxidation, these poisons were added to the reaction system while the reaction was approaching the highest rate. The kinetic curves show that, at the moment of inhibitor addition, the reaction rate decreases immediately; for AITC, the reaction is even stopped for a certain period of time. This observation proves inhibitors are adsorbed at the metal surface immediately after introduction to the system. In some cases, after decreasing the reaction rate, we have observed subsequent acceleration of the reaction that may result from depoisoning processes at the catalyst surface.

INTRODUCTION

The effects of trace amounts of substances (poisons) in oils subjected to metal catalyzed hydrogenation on the kinetics of process has been discussed in many papers devoted to the inhibitory action of sulfur and phosphorus compounds (1-14). Much less information is available on the subject of free fatty acids, sodium soaps (1,14-15) and the products of partial oil oxidation (14). In papers dealing with those compounds emphasis is mainly on the degree of metal catalyst deactivation by phospholipids, allyl isothiocyanate (AITC), free fatty acids, sodium soaps and products of lipid oxidation, whereas the kinetics of catalyst poisoning, the subject of this paper, has not been studied.

EXPERIMENTAL PROCEDURES

Materials

Refined, bleached and deodorized soybean oil was used as starting material for hydrogenation. The oil had a peroxide value (PV) of 1.5 me O_2/kg and contained 0.1% free fatty acids (FFA), 5 μg/g phospholipids (P) and 2 μg/g sodium soaps (Na).

Three types of catalyst were used: the 533-unsupported, formate type, containing 10.3% Ni (Fat Factory, Gdańsk); Nysel DM-3-supported, containing 24.8% Ni (Harshaw); and RCH 55/5-FS-supported, containing 21.0% Ni (Hoechst). The RCH catalyst was stored for a long period of time and inactivated since the experiment required a catalyst with a long induction period. Fresh RCH catalyst generally has short induction period and higher activity.

Catalyst inactivators—phospholipids, AITC, free fatty acids, their sodium soaps and the products of partial oil