Nutritive Value of Poppy Seed Protein

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ABSTRACT

The chemical and biological properties of poppy seed (*Papaver somniferum*) were studied to evaluate its possible role as a complement to or replacement for rapeseed in Sweden. A white variety of the seed contained 40% crude oil and 27% protein (N x 6.25), while a blue variety contained 33% oil and 21% protein. The amino acid composition of the two varieties were similar with chemical score values of 60 and 66, respectively. A meal was prepared by hydraulic pressing at room temperature. The protein efficiency ratio for this meal in rats was 2.34. A protein concentrate was prepared from the poppy seed meal by alkaline water extraction followed by iso-electric precipitation of protein. The freeze-dried precipitate contained 70% protein and 18% fat. Available lysine was the limiting amino acid in the protein concentrate.

INTRODUCTION

In Sweden as in many other countries, oilseeds have been used widely as sources of edible oil. During the last three decades, they also have been used as sources of crude protein for animal feed. The preponderant oilseed in Sweden during this time has been rapeseed. Owing to less favorable properties of rapeseed oil, such as the presence of erucic acid and the low content of linoleic acid, and also due to the necessity of extensive detoxification of the rapeseed meal, other alternatives have been proposed. Because of unfavorable climatic conditions, many subtropical oilseeds, such as sunflower and soybeans, cannot be grown in Sweden unless extensive plant breeding is performed. One of the few alternatives remaining is poppy oil, which has been cultivated on a small scale in Sweden since the beginning of the nineteenth century. In the last three decades, however, the seed has grown mainly for breeding and agro-technical purposes.

The fatty acid composition of poppy seed oil is more favorable than that of rapeseed oil and of a similar high quality to that of sunflower seed oil (1). Therefore, much effort is applied at present to reintroduce poppy oil in Swedish agriculture on a commercial scale. However, very little is thus far known about the nutritive quality and toxicological properties of poppy seed protein. In the present paper, some chemical and biological studies of poppy seed meals are reported, as well as physical and chemical properties of a protein concentrate prepared from poppy seeds.

TABLE I

Composition of Diets Used in Biological Determination of Nutritive Value of Poppy Seed Meal Protein

Constituents, g	Dietary group: Methionine enriched casein	Dietary group: Poppy seed meal
Casein[a]	11.5	---
Poppy seed meal[b]	---	36.5
DL-methionine	0.5	---
Corn oil	5.0	---
Salt mixture[c]	6.0	6.0
Vitamin mixture[c]	2.0	2.0
Cellulose powder[d]	4.0	---
Rice starch[e]	71.0	55.5
Total wt of diet, g	100.0	100.0
Analytical data		
Crude protein, %	10.0	10.3
Crude fat, %	5.0	5.2
Crude fiber, %	2.6	4.7

[a]High nitrogen casein, Sheffield Chemical, Union, N.J.

[b]Blue variety.

[c]See "Experimental Procedures."

[d]Munktell no. 400, Grycksbo Papperbruk A.B, Grycksbo, Sweden.

[e]Ricenta A.B, Stockholm, Sweden.

EXPERIMENTAL PROCEDURES

Preparative Methods

White poppy seeds (*Papaver somniferum*) were obtained from a local pharmacy. Blue seeds were purchased from Weibull's, Landskrona, Sweden. The hydraulic cold-pressing of oil was carried out in an apparatus which has been described previously (2). Three pressing chambers were used, and each was loaded with 700 g seeds. The pressure was increased stepwise from 0-11.1 x 10^3 kN/m^2 and maintained for up to 12 hr. The pressed cake was reduced to a meal by means of a parsley-mill (Moulin Legumes, France) and a Turmix homogenizer blender (Turmix A.G., Küsnacht, Switzerland) and used for animal experiments.

The press cake-meal obtained with the blue variety of poppy seeds also was used as the starting material for the preparation of a protein concentrate. In preliminary studies, the solubility of nitrogen over a pH range from 3-10 (pH-nitrogen solubility profiles) was determined as described by Cater, et al., (3) using distilled water as well as 1 M sodium chloride as solvents. A seed meal-solvent ratio of 1:20 was used. These solubility profiles facilitated the choice of suitable conditions for the solubilization of the poppy seed proteins. The following preparation method finally was selected: 500 g portions of the finely ground seed meal were extracted under continuous stirring at room temperature with 5000 ml distilled water and enough 1 M NaOH to bring the pH to 9.0. The extraction went on for 1 hr and during this period adjustments were made intermittently to keep the pH of the solvent constant. The extract then was centrifuged for 30 min at 3000 g in a refrigerated Stock centrifuge (+4 C). The clear supernatant was concentrated to ca. 2000 ml in a rotary vacuum evaporator, and then a protein fraction was precipitated over night at +4 C by the addition of 1 M HCl to pH 5.0. The precipitated protein fraction was collected by centrifugation for 1 hr at 3000 g (+4 C) and freeze-dried. The material prepared in this way will be referred to as the poppy seed protein concentrate.

Analytical methods

The contents of moisture, crude fiber, nitrogen, and fat were determined by standard methods (4). Amino acid analysis was performed according to the method of Spackman, et al. (5). The samples were hydrolyzed with 6 M HCl for 24 and 72 hr at 110 C. Cystine was determined by the method of Moore (6) and tryptophan using a method described by Miller (7). The estimation of available lysine was performed by a modification (A. Eklund, unpublished data) of the method of Kakade and Liener (8). Chemical score values were calculated according to Block and Mitchell (9).

Biological Evaluation of Protein Quality

Protein efficiency ratio (PER) and productive protein value (PPV) were determined for a 3 week period according to the procedure of Müller (10). The PER was calculated according to the formula: $\frac{\text{wt gain}}{\text{wt of protein eaten}}$. The PPV was defined as: $\frac{\text{nitrogen gain}}{\text{nitrogen intake}} \times 100$.

The composition of the experimental diets is presented in Table I. The vitamin and mineral mixtures were prepared according to Müller (10), except for vitamin E (α-tocopherol) which was added in larger amounts to provide 13.4 mg/100 g diet.

In the experiments, 24 day old male rats of a Sprague-Dawley strain were used. The rats were obtained from Anticimex Breeding Farm, Stockholm, Sweden. All animals were housed individually in air-conditioned and humidity and light-controlled quarters and placed after the random block principle. They were allowed free access to fresh tap water and to their respective diets. Loss of diet at consumption was negligible. At the end of the experimental period, the animals were killed, and the total body nitrogen was determined (11). The initial body nitrogen content was established in 10 experimental rats sacrificed at the start of the experiment. The data representing the increase in body nitrogen was utilized for calculation of the PPVs.

RESULTS AND DISCUSSION

Chemical Composition of Poppy Seed Meal

With blue poppy seeds, the yield of oil from the hydraulic pressing procedure depended upon seed loads of the chambers, pressure applied, and length of time under pressure. When the amount of seeds/chamber exceeded 700 g, the yield of oil decreased slightly from a maximum of 89% obtained by maintaining the pressure for a period of 7-12 hr.

The white variety of poppy seeds had a higher content of both fat (40.1%) and nitrogen (4.29%) than the blue variety (33.4% and 3.49%, respectively). The moisture content was similar in both types of seed (6-7%). The pressed cake from white seeds contained 40.6% of crude protein (N x 6.25) against 27.4% for the blue seeds. The residue oil contents after pressing were 11.5 and 13.7%, respectively.

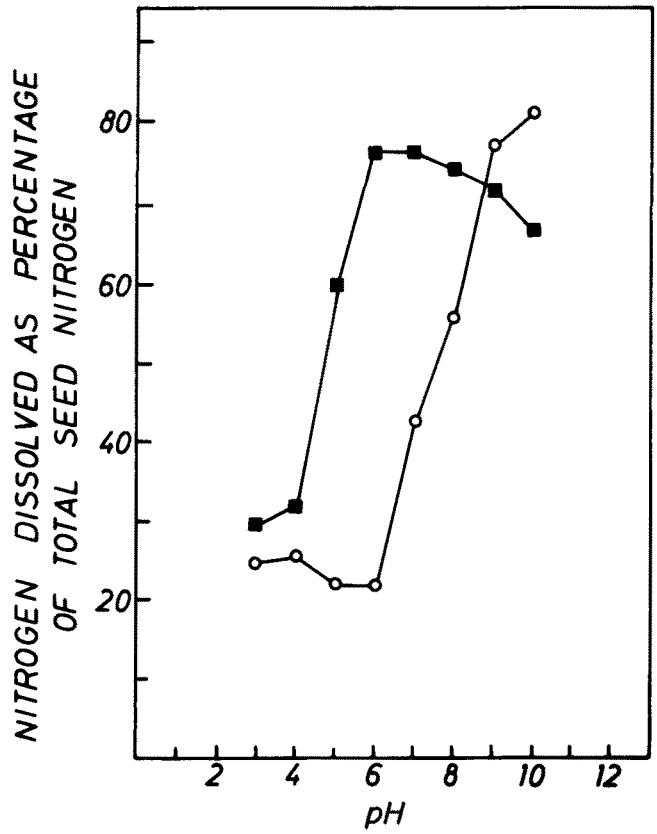

FIG. 1. Amount of nitrogen, as percentage of total seed nitrogen, dissolved from ground poppy seed press cakes (blue variety) in water (O) or 1 M NaCl (■) at different pH.

As can be seen in Table II, the amino acid compositions were rather similar in both varieties of poppy seeds. Blue seeds contained somewhat more lysine than white seeds.

TABLE II

Composition of Essential Amino Acids in Poppy Seed Meal and Protein Concentrate

		Poppy seed		
		White variety	Blue variety	
Amino acid	Egg reference pattern mg/g N	Seed meal mg/g N	Seed meal mg/g N	Protein concentrated mg/g N
Isoleucine	415	251	275	314
Leucine	553	402	429	486
Lysine	403	263	302	264
Available lysine		224	227	204
Total aromatic amino acids	627	460	511	593
Phenylalanine	365	225	257	309
Tyrosine	262	235	254	284
Total sulphur containing amino acids	346	319	293	255
Cystine	149	152	147	87
Methionine	197	167	146	168
Threonine	317	260	250	265
Tryptophan	100	71	71	80
Valine	454	334	347	407
Ratio of total essential amino acids to total nitrogen	3215	2360	2478	2664
Chemical score	100	60	66	66
Limiting amino acid		Isoleucine	Isoleucine	Lysine

TABLE III

Biological Evaluation of Protein Quality of Poppy Seed Meal (Blue Variety)

Dietary group	Protein level N x 6.25	Wt gained[a] (g)	Protein intake[a] (g)	Protein efficiency ratio[a]	Productive protein value[a]
Methionine enriched casein[b]	10.0	123.1 ± 15.7	31.7 ± 8.0	3.87 ± 0.14	65.5 ± 2.0
Poppy seed meal	10.3	69.1 ± 13.0	29.4 ± 4.0	2.34 ± 0.15	31.9 ± 2.0

[a]Male rats, 10 in each group. Values calculated for a 3 week experimental period. Means ± standard deviations.

[b]0.5 g DL-methionine/100 g diet.

The biological availability of the lysine seems to be ca. 75%.

The chemical score value was 66 in blue seed compared to 60 in white seed. In both cases, isoleucine was the first limiting amino acid. The ratios of total essential amino acids to total nitrogen were in the same range as found for many other oilseeds meals (12).

Preparation and Chemical Composition of Poppy Seed Protein Concentrate

Due to a larger supply of blue seeds in Sweden, this variety was chosen as raw material for the production of a protein concentrate despite the lower protein content.

The preliminary studies on the nitrogen solubility of poppy seed press cakes at different pH indicated that 77% of the seed protein could be dissolved in water at pH 9 and 81% at pH 10 (Fig. 1). In the pH range from 3-6, ca. 20% of the poppy seed protein seems to be soluble in water. In 1 M NaCl, the pH-nitrogen solubility profile was quite different showing the highest solubility of nitrogen (76%) in the pH range 6-7 and a slightly decreased solubility of nitrogen at more alkaline pH values.

One advantage obtained by using 1 M NaCl instead of water in the extraction of poppy seed protein would be that the process could be carried out at neutral pH. It is known that exposure of high protein products to aqueous alkali may result in the formation of unnatural amino acid derivatives, such as lysinoalanine, which may decrease the nutritive value of the product (13). Therefore, in the present preparation of a protein concentrate from poppy seed, the aqueous extraction of protein was carried out at pH 9.0 though a slightly higher solubility of protein might have been obtained in a more alkaline pH.

The protein concentrate obtained by precipitation of the extract at pH 5.0, after centrifugation and freeze-drying, had a greyish-white color and was free from unfavorable taste or flavor. It contained 70.9% crude protein, 17.9% fat, and only 1.0% crude fiber, as compared to 13.3% crude fiber in the seed meal.

The proportions of essential amino acids in the protein concentrate showed only smaller changes in comparison with the seed meal, although a decrease, from 302 mg/g N to 264 mg/g N, was noted for the lysine content (Table II). This amino acid also was found to be the first limiting amino acid in the poppy seed protein concentrate. The nitrogen content of the protein concentrate accounted for ca. 50-55% of the seed meal nitrogen. The remaining part of the seed meal nitrogen includes the undissolved protein fraction, as well as the protein fraction which did not precipitate at pH 5.0 (Fig. 1).

Biological Quality of Poppy Seed Meal Protein

The nutritive value of poppy seed protein was assessed by determining the PER and PPV values for poppy seed meal, i.e. ground press cakes, prepared from the blue variety. According to previous experiments, the reference diet used is quite similar to an egg diet with regard to the nutritive value of the protein (14). As shown in Table III, the PER value obtained with the poppy seed protein was 2.34 which corresponds to 60% of the reference diet (methionine enriched casein). This value is quite consistent with the chemical score value of 66 calculated for poppy seed protein. However, the PPV value was 31.9 which corresponds to only 49% of the PPV obtained with the reference diet. In a comparison with results previously obtained with other oilseeds, such as niger seed and sunflower seed, the PPV value of poppy seed was noteworthy low in relation both to the PER value and the chemical score (11,14,15). It seems difficult to decide at this moment which of the two methods, PER or PPV, is the true estimate of the nutritive value.

It may be noted that the PER for the poppy seed meal was of a similar value to those previously obtained for sunflower seed and some commercial soy protein products (14,15).

Since the biological quality of the poppy seed protein on the whole agreed with the chemical score value, there is no reason to suspect the presence of significant amounts of protease inhibitors or glucosinolates. The fact that the product did not change in color during the extraction of proteins in alkaline pH indicates that discolorating substances, such as chlorogenic acid and similar compounds, are not present in poppy seeds.

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