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Functional properties of sunflower seed meal obtained by ethanol extraction

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SUMMARY. The objective of this work was to determine the functional properties of sunflowerseed meal var. Anhandy obtained through ethanol intermittent oil extraction in four concentrations (99°GL, 96°GL, 93°GL and 90°GL). Meal nitrogen solubility and dispersibility, and oil absorption capacities were evaluated. The highest protein solubility (70%) was obtained in 93°GL extraction meal. 99°GL and 90°GL extracted meals showed the best water absorption performances (11.4 ml H_2O/g protein), while 96°GL meal was the best in oil absorption (7.3 ml free oil absorbed/g protein). The highest nitrogen dispersibility was found in 96°GL and 99°GL meals (1.6% dispersed nitrogen or ca. 27% yield). Nitrogen solubility essays in salt solutions indicated that pH 11 was the best; however, the yield was even lower than in aqueous solutions. Meals obtained with more concentrated ethanol-water solutions were indicated for further processing to concentrates and isolates.

RESUMEN. Propiedades funcionales de harinas de semillas de girasol obtenidas por extracción con etanol. Con este trabajo se buscó determinar las propiedades funcionales de la harina de semillas de girasol var, Anhandy, obtenida por extracción discontinua del aceite con etanol en cuatro concentraciones (99° GL, 96°GL, 93°GL y 90°GL). Fueron determinadas la solubilidad y la dispersibilidad del nitrógeno y la absorción de agua y aceite por la harina. La más alta solubilidad de proteina fue encontrada en el producto obtenido por alcohol de 93°GL, la mejor absorción de agua ocurrió en las harinas producidas con alcohol de 99°GL y 90°GL (11,4 ml H_2O/g proteina) y la mejor absorción de aceite fue detectada en la harina de 96° GL y 99°GL (1,6% N disperso, o rendimiento de 27%). Los ensayos de solubilidad en soluciones salinas apuntaron los mejores resultados a pH 11; sin embargo el rendimiento fue inferior al de las soluciones acuosas. Las harinas obtenidas con mezclas hidroalcoholicas de más alto grado fueron recomendadas para la producción de concentrados y aislados proteicos.

INTRODUCTION

Oilseed proteins are used in food formulations for human consumption in the forms of concentrates and isolates. Sunflower seeds produce an oil with excellent cooking and nutritional qualities. The seeds and meal contain many essential amino acids but are though defficient in lisine and isoleucine, they are also free from antinutritional compounds (1,2,3,4). The proteins in sunflower seeds have 90% disgestibility and 60% biological values (5). However, some inherent problems like the high hull content, and presence of cholorogenic acid that darkens the meal when under alkaline conditions, should not be forgotten (6). The highest chlorogenic acid contents are found in the kernels, which explains it is not be hulls left on the seed that impart dark green or brown colors to the protein concentrates obtained from meals, when whole seeds are processed (7,8). Reportedly, the presence of this phenolic acid does not affect the nutritional properties of the meal (6). Previous researches have demonstrated that ethanol extraction of sunflower oil is feasible (9) and that chlorogenic acid can be extracted using ethanol diluted with water (10) or by solvent mixtures (11). However, hydrated ethanol prevents total isolation of the protein (6). This protein does not seem to interact with the seed phenolic acids, in a way that reduces the yield of protein recovery (12). Minimum solubility of sunflower nitrogen compounds occurs in the range pH 3 to pH 7 (6,13,14) and maximum above pH 8 (6,15,5,16). Solubility can be enhanced by the presence of sodium or calcium ions at pH values under 8 (17,23).

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Based on findings, the objective of this work was to determine functional properties of meals produced from ethanol extractions of oil as a continuity of former research from our laboratory (9).

MATERIAL AND METHODS

Whole oil-type sunflower seeds var. Anhandy were hydraullicaly pressed and the cakes deoiled by intermittent extractions with four ethanol concentrations (99°GL, 96°GL, 93°GL and 90°GL) for eight hours at 89°C, using the equipment and process described by Regitano-d'Arce & Lima (10). The meals were prepared for this study by fine grinding in a Wiley type mill. The oil content of the meals was determined according to the Italina Norme Grassi e Derivati NGD A-4 (18). Moisture determinations were conducted according to the analytical procedures of the Instituto Adolfo Lutz (19). The total nitrogen content was determined according to the micro Kjeldahl procedure (20) and multiplied by 6.25 to estimate crude protein content. Nitrogen solubility curves were determined on 1g meal dispersed in 50 ml aqueous or saline solutions between pH values of 1 and 12, at room temperature. After shaking for one hour, pH was checked and solutions were centrifuged for 20 minutes at 350 x G. Nitrogen was determined in aliquots of the clear supernatant in micro Kjeldahl apparatus (20). The salts employed were $CaCl_2$ and NaCl. Dispersibility was determined by shaking 0.5 g meal in 25 ml distilled water at pH 7 for 15 minutes, and resting for one hour before reading. Water and oil absorption capacities were determined on 0.5 g meal homogeneized in 5 ml water (or refined soybean oil) in graduated centrifuge tubes. After a 30 minute holding period at room temperature, the tubes were centrifuged for an additional 30 minutes at 350 x G, and the volume of free water or oil was read. The retained water/g protein was calculated according to Sosulski & Fleming (21) and the absorbed oil amount/g protein was calculated according to Lin et al (22).

RESULTS AND DISCUSSION

Oil contents of the meals increased as the ethanol concentration employed in the process decreased (Tables 1 and 2). Average moisture contents of the meals were 11.7%. Figure 1 shows almost the same nitrogen solubility behavior for all the four meals studied. Minimum solubility was found between pH 3.5 and 4.5 and the maximum solubility in the narrow range of pH 11.1 and 11.6. Meal nitrogen compounds solubility rose at pH values higher than 3. The observed and expect (6) decrease in solubility was somewhat proportional to the decrease in ethanol strength used to obtain the meals. Nevertheless, close to the pH range of maximum solubility, all meals gave only 63% to 70% yields. When working with 1M $CaCl_2$ solutions (Figure 2) the solubility increased at low values as verified by Bau et al. (23). The 96°GL meals had greater yields than 99°GL meals, but both yields were lower than in aqueous solutions (max. 45.2%). pH 11 was the point of maximum solubility. When working with 0.5M $CaCl_2$ (Figure 3), an increase in solubility in the pH 3 to 6 range was noticed when compared to the 1M $CaCl_2$. With M NaCl the nitrogen compounds did not seem to be as strongly affected by the salt and solubilized in an increasing way with gradual pH increase from pH 3.5. Maximum solubility was attained by 99°GL meal at pH 12 (48.9% yield).

FIGURE 1
Sunflower meal protein solubility in water

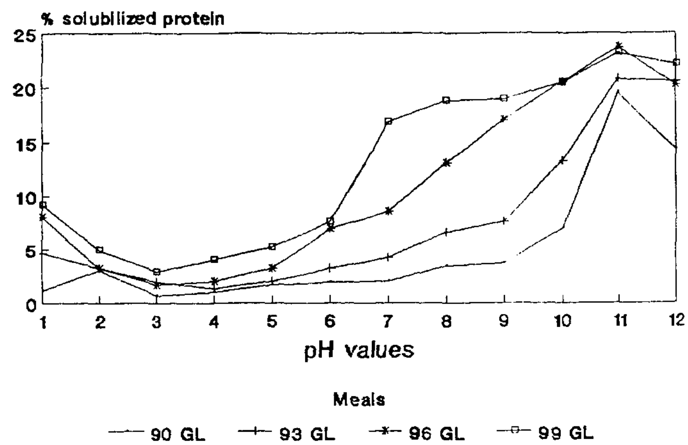

FIGURE 2
Sunflower meal protein solubility in M $CaCl_2$

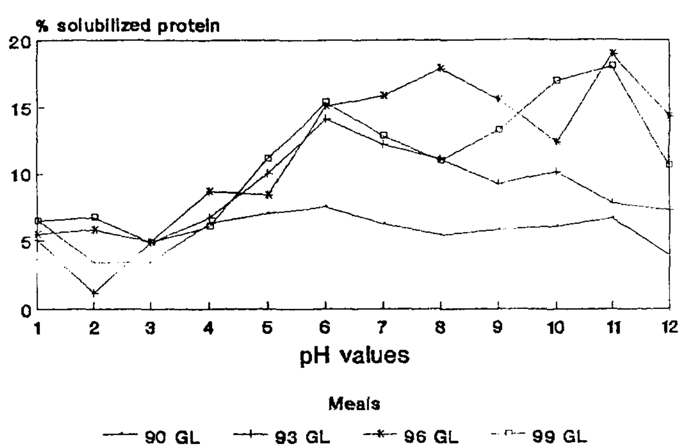

FIGURE 3
Sunflower meal protein solubility in 0.5m $CaCl_2$ and N NaCl

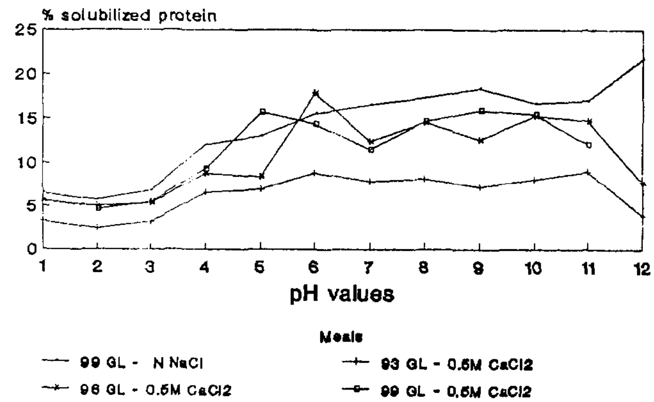

TABLE 1
COMPOSITION OF MEALS USED IN THE NITROGEN SOLUBILITY IN WATER SUSPENSION ESSAYS: OIL AND PROTEIN (N X 6.25), DRY MATTER BASIS

EtOH-Extracted meal	Oil (%)	Protein (%)
99° GL	2.0	37.0
96° GL	5.8	34.8
93° GL	12.0	29.7
90° GL	21.5	28.8

TABLE 2
COMPOSITION OF MEALS USED IN THE NITROGEN SOLUBILITY IN SALT SOLUTIONS ESSAYS: OIL AND PROTEIN (N X 6.25), DRY MATTER BASIS

EtOH-Extracted meal	Oil (%)	Protein (%)
99° GL	0.4	44.5
96° GL	0.7	41.9
93° GL	2.6	39.1
90° GL	12.7	36.1

The observations on low solubility in acid medium were confirmed by the dispersibility results (Table 3). The pH of the distilled water employed in the tests was 4.5. Meals obtained using the less hydrated ethanol had higher nitrogen dispersibilities under our conditions of work. The difference in performance is very relevant, when yield is considered (g protein dispersed/total meal protein). Nevertheless, yields are still low.

TABLE 3
PERCENTAGE OF DISPERSED NITROGEN IN THE MEALS FROM TABLE 2, AND YIELD IN % PROTEIN DISPERSED % PROTEIN MEAL X 100

	EtOH-Extracted meals			
	99°G	L96°GL	93°GL	90°GL
% N	1.60	1.62	0.66	0.67
Yield (%)	27.7	25.9	9.8	9.4

Table 4 shows that water absorption is proportional to the protein content of the meal, in accordance with Fleming et al. (24). When considering oil absorption capacity, a relative tendence to absorb more oil, at higher oil contents in the meals (in ml oil/g protein) was observed.

This initial evaluation indicated that sunflower meals obtained from whole seeds extracted with ethanol can be employed in food industries either for protein isolate production or for its protein participation in food formulations.

TABLE 4
WATER AND OIL ABSORPTION CAPACITIES OF MEALS FROM TABLE 2 IN ML WATER OR OIL/G PROTEIN OR PER G MEAL

	EtOH-Extracted meals			
	99°GL	96°GL	93°GL	90°GL
H_2O content	5.07	4.57	4.26	4.12
H_2O absorption	11.4	10.9	10.9	11.4
Oil content	2.67	3.06	2.23	2.27
Oil absorption	6.0	7.3	5.7	6.3

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REFERENCES

1. Earle FR, CH Vanetten, TF Clark & IA Wolf. Compositional data on sunflower seed. J am Oil Chem Soc 45:876-879, 1968.
2. Galoppini, C & R Fiorentini. Composizione del seme di girasole con particolare riferimento ai constituenti proteici. En: Il girasole -una fonte di protein e alimentari. Milano, Consiglio Nazionale delle Richerche, 1981, p. 37-50.
3. Lanzani A, M Cardilo & MC Petrini. Tecnologie per la preparazione di prodotti proteici da farine di girasole. En: Il girasole -una fonte di protein e alimentari. Milano, Consiglio Nazionale delle Richerche, 1981, p. 61-76.
4. Robertson JA. Sunflowers: America's neglected crop. J Am Oil Chem Soc 49:239-244, 1972.
5. Roberston JA. Use of sunflower seed in food products. Crit Rev Food Sci Nutr 6:201-240, 1975.
6. Smith AK & VL Johnsen. Sunflower seed protein. Cereal Chem 25:399-406, 1948.
7. Brummett, BJ & EE Burns. Pigment and chromogen characteristics of sunflower seed. J Food Sci 37:1-3, 1972.
8. Burns EE, LJ Talley & BJ Brumentt. Sunflower utilization in human foods. Cereal Sci Today 17:287-289, 298, 1972.
9. Regitano-d'Arce, MAB. Ensaios de extração de óleo de girassol (*Helianthus annuus* L.) com álcool etílico. [Master's Dissertation] Piracicaba, ESALQ/USP, 133p, 1985.
10. Regitano-d'Arce, MAB & UA Lima. Emprego do álcool etílico na extração de óleo de sementes de girassol (*Helianthus annuus* L.). Ciencia Tecnolg Alim, 7:1-14, 1987.
11. Rossi M, C Peri & M Riva. Produzione di farine proteiche da girasole. II. Estrazione combinata dell'oleo e dell'acido clorogenico. Riv Ital Sostanze Grasse, 57:509-512, 1980.
12. Cater, CMS, S Gheyasuddin & KF Mattil. The effect of chlorogenic quinic and caffeic acids on the solubility and color of protein isolates especially from sunflower seed. Cereal Chem, 49:508-514, 1972.
13. Gheysuddin S, CM Cater & KF Mattil Effect of several variables on the extractability of sunflower seed proteins. J Fd Sci, 35:453-456, 1970.
14. Rahma EH & MS Narasing Rao. Characterization of sunflower proteins. J Food Sci, 44:579-582, 1979.
15. Kilara A, ES Humbert & FW Sosulski, Nitrogen extractability and moisture adsorptive characteristics of sunflower seed products. J Food Sci, 37:771-773, 1972.
16. Madhusudhan KT & H Srinivas. Effect of roasting on the functional properties of sunflower meal. Lebensm Wiss Techn, 20:8-11, 1986.
17. Rossi M & C Peri. Utilizzazione nell' alimentazione unama di farine, concentrati e isolati e formulazione. En: Il girasole -una fonte di proteine alimentari. Milano, consiglio Nazionale delle Richerche, p. 89-105, 1981.
18. Stazione Sperimentale per le Industrie degli Oli e dei Grassi. Norme Grassi e Derivati. Milano, SSOG, 1976.
19. Instituto Adolfo Lutz. Normas analíticas, v. Métodos químicos e físicos para análises de alimentos. 3ed. São Paulo, IAL, p. 21, 1985.
20. Association of Official Analitical Chemists. Official methods of analysis of the AOAC. 11th ed. Washington, DC, The Association, p. 16, 1970.
21. Sosulski F & SE Fleming. Chemical, functional and nutritional properties of sunflower protein products. J Am Oil Chem Soc, 54:100A-104A, 1977.
22. Lin MJ, ES Humbert & FW Sosulski. Certain functional properties of sunflower meal products. J Food Sci, 39:368-370, 1975.
23. Bau HM, DJ Mohtadi-nia, L Mejean & G Debry. Preparation of colorless sunflower protein products: effect of processing on physicochemical and nutritional properties. J Am Oil Chem Soc, 60:1141-1148, 1983.
24. Fleming SE, FW Sosulski, AE Kilara & ES Humbert. Viscosity and water absorption characteristics of slurries of sunflower and soybean flours, concentrates and isolates. J Food Sci, 39:188-181, 1974.

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