Functional Properties of Guar (*Cyamopsis tetragonoloba*) Meal Protein Isolates

Razia Tasneem and N. Subramanian*

Functional properties of the protein isolates obtained from detoxified guar meals have been compared with those of the defatted guar meal protein isolate. All samples exhibited U-shaped nitrogen solubility vs. pH profiles with maximum solubilities (80%) at extreme acidic and alkaline regions and minimum solubility (2%) at pH 5. The protein isolates from the aqueous alcohol-extracted and autoclaved meals had lower water absorption capacities (74–98 g/100-g sample) while 1 and 0.25 N HCl extracted meal isolates had significantly higher values of 187 and 180 g/100-g sample, respectively. The fat absorption capacities (g/100-g sample) of the various isolates obtained from treated flours were in the range 105–133 while the value of the defatted meal isolate was 108. The foam capacity (percent volume increase) of the 2-propanol-extracted meal isolate was 150 compared to a value of 125 for the control while the other detoxified meal isolates had lower foam capacities. The foam stability (percent foam volume), at 30 min after whipping, of the various samples ranged from 48 to 63, the highest value being for the defatted meal isolate. The defatted guar meal isolate had an emulsification capacity (mL of oil emulsified/g of sample) of 65 while the values for the other isolates ranged from 56 to 72.

INTRODUCTION

Proteins not only provide a nutritional component in a food system but also perform a number of other functions. The most important attribute of a protein is its variouis functional properties. The functional properties are inherent in the proteins, but the method of protein isolation as well as the source has some effect on the functional quality of the product. Many processes used for extracting and preparing seeds protein concentrates/isolates cause denaturation and alter their functional properties. The detoxification of guar meal and its functional properties as affected by treatments such as dilute acid leaching, aqueous alcohol extractions, and autoclaving have been reported earlier (Tasneem et al., 1982). Since constituents other than proteins such as carbohydrates, lipids, fiber, etc., may also influence the functional properties of proteins (Yasumatsu et al., 1972; McWatters and Cherry, 1977; Deshpande et al., 1982), it was of interest to study the functional properties of the protein isolates obtained from processed guar meals, which contain a relatively low concentration of these components. In this investigation some of the functional properties of the protein isolates obtained from detoxified guar meals have been compared with those of the isolate from control defatted meal.

MATERIALS AND METHODS

Guar seed of the variety Durgapur safed procured from a guar gum industry was used in the study. Processing of guar seed to obtain guar meals and the preparation of defatted and detoxified guar meals were done as reported earlier (Tasneem et al., 1982).

Preparation of Protein Isolates. Protein isolates from the defatted and detoxified guar meals were prepared by alkali extraction followed by isoelectric precipitation. For the peptization the meal was suspended in distilled water (meal to water ratio being 1:10), and the dispersion was stirred for 15 min. The dispersion was raised to pH 9 by adding 6 N NaOH and stirring continued for another 60 min. The dispersion was centrifuged at 8000*g* to remove the residue, and the protein was precipitated at the isoelectric point (pH 5) by adjusting the pH of the centrifuged liquor with 6 N HCl. The wet protein isolate was recovered by centrifugation and redispersed in a sufficient amount of water, and the pH of the slurry was adjusted to 7 with 2 N NaOH. The neutralized proteinate was freeze-dried and ground to pass through 60-mesh sieves.

Nitrogen Solubility (NS). To 2 g of protein isolate was added 15 mL of distilled water and the pH of the dispersion adjusted to the desired value (pH 2–11) by adding 1 N HCl or 1 N NaOH (x mL). An aliquot, equivalent to $5 - x$ mL of water was further added so that the meal to solvent ratio was 1:10. The dispersion was stirred for 1 h and then centrifuged at 4000*g* for 20 min. The pH of the suspension was noted and its nitrogen content determined by the micro Kjeldahl method. The percent of the total nitrogen extracted was calculated and plotted as a function of pH.

Water Absorption Capacity (WAC). Since the isolates had very high solubilities at neutral pH, the WAC values were determined at pH 5, the pH of minimum solubility. The method of Sosulski (1962) was used to determine the WAC, and the values were expressed as the amount of water retained by a 100-g sample.

Fat Absorption Capacity (FAC). The method of Sosulski et al. (1976) was used to determine the FAC of the guar meal protein isolates, and the values were expressed as the amount of oil (*g*) absorbed by a 100-*g* sample.

Foam Capacity (FC) and Foam Stability (FS). The sample (5 g) was taken with 100 mL of water in an electric blender (Braun), and the dispersion was blended for 5 min and immediately transferred into a 250-mL measuring cylinder. The total (liquid and foam) and the liquid volumes were recorded at 0.5 and 30 min after whipping. The FC expressed as percent volume increase at 0.5 min after whipping and FS expressed as percent foam volume after 30 min were determined according to the methods of Lawhon et al. (1972) and Ahmed and Schmidt (1979), respectively.

Emulsification Capacity (EC). The EC values of the various protein isolates were determined according to the method of Beuchat et al. (1975). The values were expressed as milliliters of oil emulsified/gram of sample.

RESULTS AND DISCUSSION

Yield Data of Protein Isolates. The yield of the isolate from the defatted meal was 44% on a dry-matter

Central Food Technological Research Institute, Mysore 570013, India.

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Table I. Yield Data of Protein Isolates Obtained from Processed Guar Meals

protein isolate from	yield, g/100 g meal	N content, g/100 g isolate	N rec, g/100 g meal N
defatted gaur meal	44	14.64	59
1 N HCl extr guar meal	36	13.33	39
0.25 N HCl extr guar meal	31	13.85	33
80% ethanol extr guar meal	45	15.90	55
70% methanol extr guar meal	46	15.45	53
80% 2-propanol extr guar meal	44	15.43	55
autoclaved guar meal	26	14.60	35

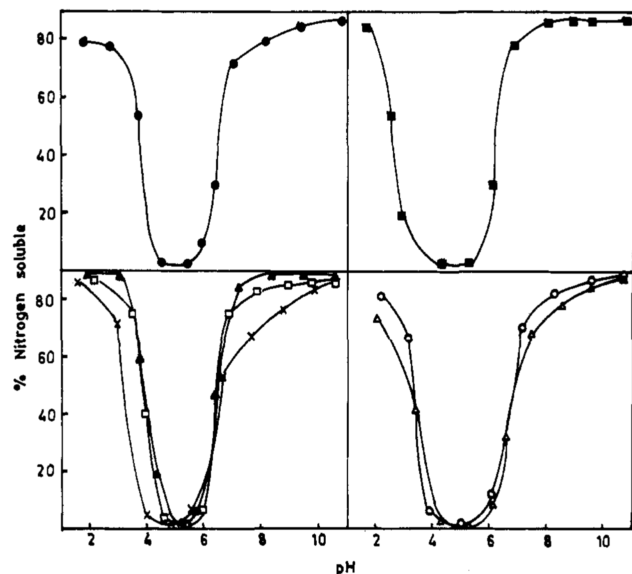

Figure 1. Nitrogen solubility of protein isolates from processed guar meals: (●) defatted guar meal protein isolate; (■) autoclaved guar meal protein isolate; (□) 80% ethanol extracted guar meal protein isolate; (×) 70% methanol extracted guar meal protein isolate; (▲) 80% 2-propanal extracted guar meal protein isolate; (○) 1 N HCl extracted guar meal protein isolate; (△) 0.25 N HCl extracted guar meal protein isolate.

basis and 59% on a nitrogen basis (Table I). In the case of the isolate from autoclaved meal, the yield as well as the nitrogen recovered in it were low due to the heat denaturation of proteins that affects nitrogen extractability. The yield and the nitrogen recovery of the isolates from the acid-extracted meals also were low as compared to those of the isolate from the defatted meal. The loss of acid-soluble proteins coupled with the acid denaturation of the proteins, during the detoxification treatments, might be responsible for the low values. Although the yields of the isolates from the aqueous alcohol extracted meals were comparable with that of the defatted meal isolate, the nitrogen recovered in these was comparatively low. This would indicate the denaturing effect of the alcohols on guar proteins and their extractability.

Nitrogen Solubility. The guar meal protein isolates, as in the case of meals (Tasneem et al., 1982), exhibited U-shaped NS vs. pH profiles (Figure 1). They showed very high solubilities of 80–90% at extreme acidic and alkaline regions (pH 2 or 9) and a minimum of about 2% around the isoelectric point (pH 5). At neutral pH, nitrogen extracted from the acid-extracted and aqueous methanol-extracted meal protein isolates was only about 55% while from the other isolates more than 70% of the nitrogen could be extracted. Although the protein isolates were prepared by extracting the meal proteins at pH 9 followed by isoelectric precipitation and neutralization, none of the isolates showed NS values greater than 90% at and above pH 9. This might be due to the denaturation

Table II. Water Absorption, Fat Absorption, and Emulsification Capacities of Protein Isolates Obtained from Processed Guar Meals

sample isolate from	water abs cap., g/100-g sample	fat abs cap., g/100-g sample	emulsificn cap., mL oil emulsif/g sample
defatted guar meal	101	108	65
1 N HCl extr guar meal	187	109	62
0.25 N HCl extr guar meal	180	133	64
80% ethanol extr guar meal	82	131	57
70% methanol extr guar meal	95	130	56
80% 2-propanol extr guar meal	74	128	72
autoclaved guar meal	98	105	67

of the proteins caused by acidic conditions during precipitation of the proteins. A similar effect has been reported for soybean proteins (Anderson, 1974; Wolf, 1977). At the pH of minimum solubility, the NS of all the isolates was only 2% against 5–12% for the meals (Tasneem et al., 1982). This is due to the removal of nonprotein nitrogeneous material during the preparation of the isolates.

Water Absorption Capacity. The WAC of the protein isolate from autoclaved guar meal (98) was comparable to that of the isolate from the defatted meal (101) while the values for the isolates from the aqueous alcohol extracted meals ranged from 74 to 95 (Table II). The isolates from the 1 and 0.25 N HCl extracted meals had very high WAC, the values being 187 and 180, respectively. This might be due to the acid denaturation, dissociation, and unfolding of the proteins that might result in the exposure of the hydrophillic groups to the surface. However, the values for all the isolates were much lower than those for the respective meals (Tasneem et al., 1982) from which these isolates were prepared, indicating that constituents other than proteins such as carbohydrates also influence water absorption.

Fat Absorption Capacity. The FAC of the protein isolate from the defatted guar meal was 108. The values for the isolates from the 1 N HCl extracted meal and autoclaved meal were comparable with that of the defatted meal isolate (Table II). The FAC values of the other isolates were comparatively higher, being in the range 128–133. Also, the FAC values of all the isolates were higher than those of the respective meals (Tasneem et al., 1982). This might be attributed to the higher protein contents of the isolates compared to those of the respective meals. Hutton and Campbell (1977) also reported that the absorption of fat by soy protein isolate was higher than that of the soy protein concentrate and suggested that the protein was largely responsible for fat absorption. However, in the case of guar sample a strict correlation between the increase in protein content and the FAC values of the protein isolates was not observed.

Foam Capacity. The FC of the protein isolates from the detoxified meals except the 2-propanol extracted meals ranged from 94 to 117 against 125 for the control defatted meal isolate (Figure 2). The significantly higher FC (150) of the aqueous 2-propanol extracted meal isolate could be due to its higher NS at pH 7. The isolates showed higher FC values than the respective meals (Tasneem et al., 1982), and this difference was higher in the case of the acid-extracted meals and their isolates than for other samples. The FC of the protein isolate from 1 N HCl extracted meal was nearly 4 times and that of the isolate from 0.25 N HCl extracted meal was about 2.5 times higher than those of

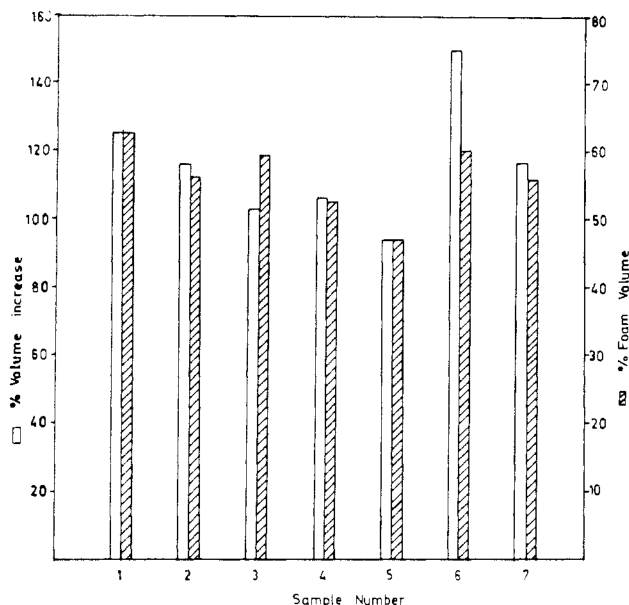

Figure 2. Foam capacity (□) and foam stability (▨) of protein isolates obtained from processed guar meals: (1) protein isolate from defatted guar meal; (2) protein isolate from 1 N HCl extracted guar meal; (3) protein isolate from 0.25 N HCl extracted guar meal; (4) protein isolate from 80% ethanol extracted guar meal; (5) protein isolate from 70% methanol extracted guar meal; (6) protein isolate from 80% 2-propanol extracted guar meal; (7) protein isolate from autoclaved guar meal.

the respective meals. The acid-extracted meals having very low FC values thus yielded protein isolates that were comparable with the isolates from other guar meals in their foaming properties. The higher protein contents and higher NS of the isolates might be responsible for the higher FC values of the isolates compared to the respective meals. Although the FC values are greatly influenced by the processing steps involved in the preparation of a sample, in soybean samples also, it was reported that the protein isolates were superior to the flours or concentrates in their foaming properties (Fleming et al., 1974; Lin et al., 1974).

Foam Stability. The FS of the protein isolate from the defatted guar meal was 62 while those for the other isolates were in the range 47–60 (Figure 2). Among the isolates from the detoxified meals, the methanol extracted meal isolate had the minumum FS (47) while the 2-propanol extracted meal protein isolate had the maximum FS (60). However, the values for the isolates from the acid-extracted and autoclaved meals were comparable (55–59).

Emulsification Capacity. The EC of the protein isolates from various guar meals ranged from 56 to 72 (Table II), the value for the isolate from the defatted meal being 65. The isolates from autoclaved and acid-extracted meals had EC values in the range 62–67, which were comparable to that of the isolate from defatted meal. The values of the isolates from methanol extracted and ethanol extracted meals (~56) were lower than that of the defatted meal isolate while the 2-propanol extracted meal isolate had the highest EC (72), which might be due to its higher NS at pH 7. The EC values of the protein isolates were higher than those of the respective meals (Tasneem et al., 1982); the acid-extracted meals and their protein isolates showed the maximum difference. This might be due to the higher protein contents and higher solubilities of the isolates. The differences in the contents of other constituents such as carbohydrates, lipids, and crude fiber in the meals and isolates might also contribute to this variation in the EC values. There are reports in literature that indicate that constituents other than protein are also responsible for the emulsification properties. McWatters and Cherry (1977) reported that the high carbohydrate content of cowpeas might influence emulsion, foaming, and thickening properties. Yasumatsu et al. (1972) reported that the emulsification capacities of soybean products correlated positively with the protein content and negatively with the fiber content. Deshpande et al. (1982) suggested that functional properties apparently cannot be solely attributed to the proteins, and other components such as carbohydrates and lipids may also contribute appreciably, possibly through protein–carbohydrate and protein–lipid interactions.

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