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Functional properties and nutritional quality of acetylated and succinylated mung bean protein isolate

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Abstract

Mung bean protein isolate was acylated to various degrees by acetic and succinic anhydrides. Changes in functional properties (protein solubility index in different solutions, water and oil absorption capacities, emulsification properties, foam capacity and stability), antinutritional factors (tannins, phytic acid and trypsin inhibitor) and in-vitro protein digestibility of acylated protein isolate were determined. The modification rate with acetic anhydride was greater than with succinic anhydride. Succinylation significantly increased the protein solubility index in water and 1 M NaCl whereas acetylation decreased it in water. Acetylation and succinylation caused significant increases in water and oil absorption capacities. Foam capacity and foam stability (up to 0.4 g anhydrides/g protein) were significantly increased due to acylation. Significant increase was observed in emulsification capacity and emulsification stability (up to 0.8 g acetic and 0.6 g succinic anhydrides/g protein) by acylation; however, emulsification activity was significantly decreased over 0.6 g anhydrides/g protein. Acetylation is more effective for reduction of antinutritional factors than succinylation. Also, acetylation is more effective in improving the in-vitro protein digestibility than is succinylation.

Keywords: Mung bean; protein isolate; Chemical modification; Functional properties; Antinutritional factors; In-vitro protein digestibility

1. Introduction

In Egypt, mung bean (*Phaseolus aureus*) has been introduced recently by the Ministry of Agriculture. Mung bean is an excellent source of protein (27%), and its essential amino acid composition compares favourably with that of soybean, kidney bean and FAO/WHO reference protein (El-Adawy, 1996; Evans & Bandermer, 1974; Fan & Sosulski, 1974; Thompson, Hung, Wang, Rapser & Gade, 1976). However, antinutritional factors and dark colour limit the food applications of mung bean. Therefore, dehulling of the seeds before milling as well as preparation of protein isolate have been used to overcome these problems (El-Adawy, 1996; Thompson et al., 1976). Mung bean protein isolate has been shown to perform many desirable functions in processed foods, such as foaming, emulsification and water absorption (El-Adawy, 1996). However, improvements in those functions would make mung bean protein isolate more desirable as a food component.

Chemical modification is one method proposed to improve the functional properties of the proteins for food processing (Li-Chan, Helbig, Holbeck, Chan & Nakai, 1979; Matheis & Whitaker, 1984). Chemical modification, particularly acylation with acetic and succinic anhydrides, has been used to improve functional properties of many plant proteins including wheat (Grant, 1973), soybean (Franzen and Kinsella, 1976a), leaf protein (Franzen & Kinsella, 1976b; Sheen, 1991), peanut (Beuchat, 1977), sunflower (Kabirrullah & Wills, 1982; Schwenke & Rauschal, 1983), pea (Johnson & Brekke, 1983; Schwenke, Zirwer, Gast, Görnitz, Linow & Gueguen, 1990), cottonseed (Choi, Lusas & Rhee, 1981; Rahma & Narasinga Rao, 1983), winged bean (Narayana & Narasinga Rao, 1984), faba bean (Krause, Mothes & Schwenke, 1996; Muschiolik, 1989; Muschiolik, Dickinson, Murray, & Stainsby, 1987; Rauschal, Linow, Pähtz & Schwenke, 1981; Schwenke, Dudek, Mothes; Raab & Seifert, 1993), soy glycinin (Kim & Rhee, 1990; Kim & Rhee, 1991), rapeseed (Dua, Mahajan & Mahajan, 1996; Gruener & Ismond, 1997; Gueguen, Bollecker, Schwenke & Raab, 1990), chickpea (Liu & Hung, 1998).

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No literature data are available on acylation of mung bean proteins.

Acylated proteins have been applied in preparation of some products such as coffee whiteners (Melychyn & Stapley, 1973), flavouring agents for roasted meat (Mosher, 1974), carbonated beverages (Creamer, Roeper & Lohrey, 1971), mayonnaise and salad dressings (Evans & Irons, 1971) margarine and ice cream (Evans, 1970) and cheese-like gels (Chen, Richardson & Amundson, 1975).

The most common chemical modification used for proteins has been the acetylation and succinylation of amino acid residues, particularly lysine. Acetylation of ε-amino groups of lysine residues renders them electrically natural, whereas, acetylation decreased the number of positive charges by substituting hydrophobic acetyl groups for the positively charged ε-amino groups. However, succinylation introduces anionic succinate residues covalently linked to the ε-amino groups of lysine residues (Fig. 1). The resulting change from positive to negative charge leads to greater changes in electrostatic relationships and frequently brings about the dissociation of aggregated or subunit proteins and/or rather major conformational changes. Therefore, succinylation is sometimes preferable to acetylation for the modification of amino groups because, in some cases, products of the former are likely to be more soluble (Means & Feeney, 1973).

The improvements in functional properties of proteins have been attributed to conformational changes in the protein molecules. The related changes in functionality are affected by the extent of acylation. Extensive acylation increased hydrophobicity of soy glycinin while moderately acylated glycinin showed low hydrophobicity (Kim & Rhee, 1989). Fat absorption of winged bean was related to the degree of acylation (Narayana & Narasinga Rao, 1984). Barman, Hansen and Mossey (1977) showed that varying degree of acylation could alter the functional properties of soy protein. Therefore, acylation provides a means of improving the functionality of mung bean protein isolate and may enable further understanding of its behaviour in food systems. The present study was undertaken to evaluate the effect of progressive acetylation and succinylation on the antinutritional factors, in-vitro protein digestibility and functional properties of mung bean protein isolate.

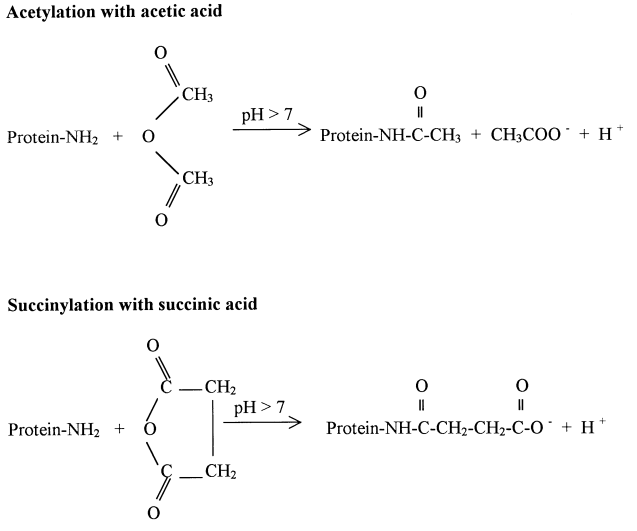

Fig. 1. Reaction of acetic and succinic anhydrides with the ε-amino group of lysine.

2. Materials and methods

2.1. Materials

Mung bean seeds (*Phaseolus aureus*), variety Giza-1 (VC. 2010), were obtained from the Agriculture Research Center, Seed Department, Giza, Egypt. The seeds were cleaned by hand to remove the foreign materials and ground into 60-mesh (British Standard Screen) flour using a household flourmill (Braun, Germany).

Acetic and succinic anhydrides were obtained from E. Merck, Germany. Trypsin (Type I), pancreatin (P-1750) and 2,4,6-trinitrobenzenesulfonic acid (TNBS) were obtained from Sigma Chemical Co., St. Louis, MO. All other chemicals used were of reagent grade.

2.2. Preparation of mung bean protein isolate

Protein isolate was prepared using the methods described by Johnson and Brekke (1983), as modified by El-Adawy (1996). Dispersions of 5% (w/v) mung bean flour in water were adjusted to pH 9 with 0.1 N NaOH at room temperature (~30°C), shaken for 1 h and centrifuged for 15 min at 2000×*g*. In order to obtain increased yields, the extraction and centrifugation procedures were repeated on the residue. The extracts were combined and the pH adjusted to 4.5 with 1 N HCl to precipitate the protein. The proteins were recovered by centrifugation at 2000×*g* for 15 min followed by removal of the supernatant by decantation. Protein curd was washed with distilled water and the curd was redispersed in distilled water. The average yield of protein isolated from mung bean flour was 13 g protein/100 g flour, as gravimetrically determined.

2.3. Acylation of mung bean protein isolate

Mung bean protein isolate was acylated by reaction with succinic and acetic anhydrides, separately, by adding different concentrations of these reagents (0.2, 0.4, 0.6, 0.8 and 1.0 g of anhydride/g of protein) at pH 8. The slurry was left for 2 h at room temperature; it was then dialyzed against distilled water for 48 h at 2–3°C

and freeze-dried. Control was treated in the same manner except that no modifying reagents were added.

2.4. Determination of chemical modification and total protein

The extent of chemical modification was estimated by determining the available lysine content of the protein by the procedure of Fields (1972) using 2,4,6-trinitrobenzenesulfonic acid (TNBS). Modification is expressed as percent reduction in available lysine residues. The total protein ($N\times6.25$) was measured by the standard micro-Kjeldahl method (AOAC, 1990).

2.5. Functional properties

Protein solubility in distilled water and 1.0 M sodium chloride solution was determined by the method described by Rahma and Narasinga Rao (1979). Water and oil absorption capacities were estimated according to Sosulski (1962) and Sosulski, Humbert, Bui and Jones, (1976), respectively, and expressed as grams of water or millilitres of sunflower oil bound per 100 g of protein isolate. Foam capacity and foam stability were assessed according to the method of Lawhon, Rooney, Carter and Matti (1972) using 1% protein solution in a Braun blender at 1600 rpm for 5 min. The percentage increase in foam volume was recorded as foam capacity. The change in volume of foam after 15, 30, 45 and 60 min of standing at room temperature (~30°C) was recorded as foam stability. Emulsification capacity (millilitre oil/g protein) was determined as described by Beuchat, Cherry and Quinin, (1975). Emulsifying activity and emulsion stability were estimated by the method of Yasumatsu et al., (1972). Briefly, 10 ml of sunflower oil were added to 10 ml of protein solution (10%) and homogenized for 2 min in Bruan blender at 7000 rpm. The emulsion was then divided evenly into two 12-ml centrifuge tube and centrifuged at $2000\times g$ for 5 min. Emulsifying activity was expressed as the (height of emulsified layer/the height of total contents in the tube)×100. Emulsion stability was determined by centrifugation after heating at 80°C for 30 min and was expressed as the (height of emulsified layer after heating/the height of total contents in the tube) × 100.

2.6. In-vitro protein digestibility

This was determined by the methods of Salgó, Granzler and Jecsai (1984) using trypsin and pancreatin enzymes.

2.7. Antinutritional factors

Phytic acid was estimated according to the method of Wheeler and Ferrel (1971). Total tannins were determined colorimetrically as described by AOAC (1990). Trypsin inhibitor activity was determined as described by Kakade, Simons and Liener (1969) using Benzyol-DL-arginine-*p*-nitroanalide hydrochloric as substrate.

2.8. Statistical analysis

The experiments were performed in triplicate and the means of three values were reported. Data were statistically analyzed using analysis of variance and least significant difference (Steel & Torrie, 1980). Significant differences were determined at the $P\leqslant0.05$ level.

3. Results and discussion

3.1. Extent of modification

The amount of free lysine available to react with TNBS in untreated and acylated mung bean protein isolate was used to determine the extent of modification, and the results are shown in Fig. 2. The extent of lysine modification increased as the levels of succinic anhydride or acetic anhydride added to the protein increased. The modification rate with acetic anhydride was greater than with succinic anhydride at all levels used. At the highest level of acetic anhydride (1.0 g/g protein) nearly 91.0% of the lysine residues had been modified whereas, at the

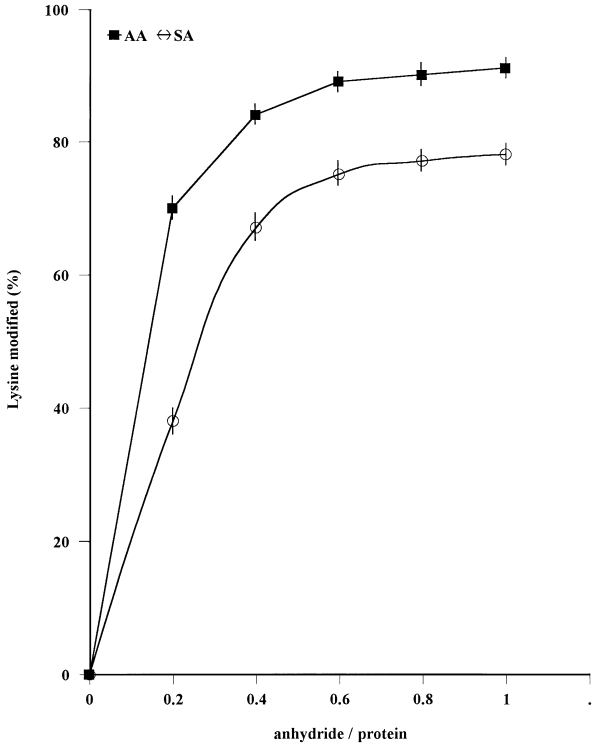

Fig. 2. Effect of various concentrations of acetic anhydride (AA) and succinic anhydride (SA) on percent lysine modified of mung bean protein isolate.

same level of succinic anhydride, only about 78.0% modification had occurred. Thus acetic anhydride appeared to be a better acylating agent for mung bean protein isolate than succinic anhydride. Eisele and Brekke (1981) found that acetic anhydride was the most reactive acetylation reagent, compared with succinic, benzentricarboxylic anhydride and tetra tetrahyrofurantetracarboxylic dianhydride. Dua et al. (1996) reported that rapeseed protein meal was more reactive with acetic (89.7%) than succinic (>83%) anhydride. However, Narayana and Narasinga Rao (1984) found no significant difference in the effects of acetic and succinic anhydrides on acylated winged bean flour.

Generally, hydrophilic groups of the amino acid residues, such as sulfhydryl, phenol, imidazole, hydroxyl and ε-amino group could be acylated. The ε-amino group was most reactive because of its low pK and low steric hindrance. Acetic anhydride was usually more reactive than other acylating agents because of its solubility and maybe its lower steric hindrance.

3.2. Protein solubility index

The protein solubility indices of acetylated and succinylated mung bean protein isolate in distilled water and 1.0 M sodium chloride are shown in Fig. 3. Succinylation caused a significant increase ($P \leqslant 0.05$) in protein solubility index of mung bean protein isolate in distilled water. Also, acetylation significantly ($P \leqslant 0.05$) improved the protein solubility index, however, this increase was not as pronounced as with succinylated samples. In 1.0 M sodium chloride the protein solubility index; of acetylated protein isolate was significantly decreased ($P \leqslant 0.05$) while succinylated protein isolate showed a significant increase ($P \leqslant 0.05$) at all modification levels. Generally, the better solubility index of succinylated mung bean protein isolates than acetylated ones can be explained by the facts that succinylation introduces longer side chains compared with acetylation, produces more electrostatic repulsions in the protein, and produces greater change in conformation, which results in better protein–water interactions. Succinylation increased protein solubility index of glandless cottonseed flour in water and 4% sodium chloride (Choi, Lusas & Rhee, 1981). However, acetylation cottonseed protein was shown to decrease its protein solubility index (Rahma & Narasinga Rao, 1983).

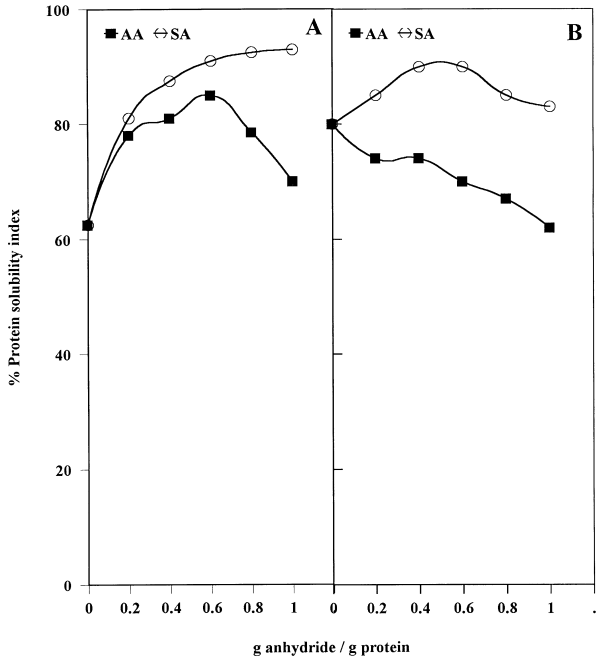

Fig. 3. Effects of various concentrations of acetic anhydride (AA) and succinic anhydride (SA) on protein solubility index of mung bean protein isolate in distilled water (A) and 1 M sodium chloride (B). Least significnat difference (LSD) at 5% was 3.57 for solubility in water and 3.65 for solubility in 1 M sodium chloride.

3.3. Water absorption capacity

The water absorption capacities of succinylated and acetylated mung bean protein isolate are shown in Fig. 4. Acetylation and succinylation significantly increased ($P \leqslant 0.05$) the water absorption capacity at all levels of modification compared to untreated protein isolate. Further, succinylation decreased water absorption

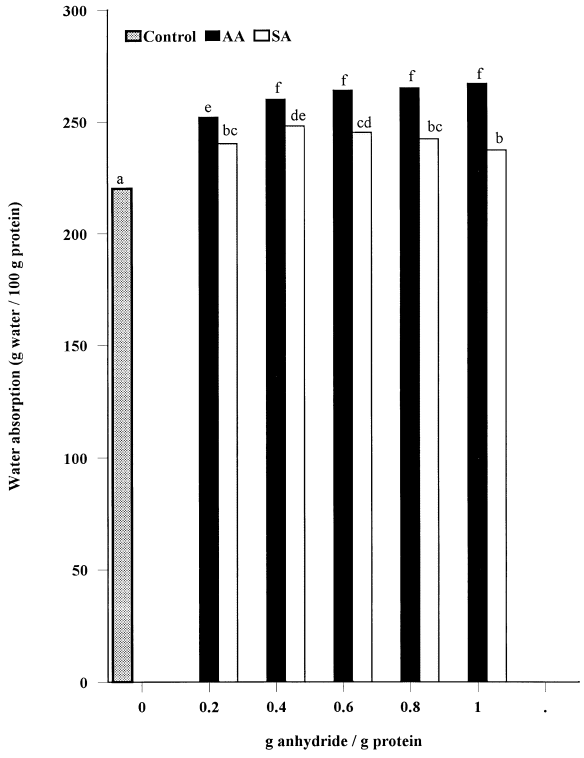

Fig. 4. Effects of various concentrations of acetic anhydride (AA) and succinic anhydride (SA) on water absorption capacity of mung bean protein isolate. Values followed by the same letter are not sifnificantly different ($P < 0.05$). Least significant difference (LSD) at 5% = 4.45.

capacity at high succinic anhydride concentrations (0.6 to 1.0 g/g protein); however, it was still higher than untreated mung bean protein isolate. Acylation can cause dissociation and unfolding of the protein might expose more hydrophilic groups than hydrophobic, thereby increasing the hydrophilic binding sides. The lower water absorption capacities of succinylated protein isolates than acetylated protein isolates may be due to higher solubility of the succinylated protein. It has been reported that highly soluble protein exhibits poor water absorption (Hermansson, 1973). The increase in water absorption capacity by acylation has been reported by Liu and Hung (1998) for chickpea proteins and Dua et al. (1996) for rapeseed flour.

3.4. Oil absorption capacity

The oil absorption capacity of acylated mung bean protein isolate is shown in Fig. 5. Significant increase ($P \leqslant 0.05$) was observed in oil absorption capacity at all levels of acetic and succinic anhydrides compared to untreated protein isolate. However, oil absorption was not markedly affected at high levels of acetic anhydride; it was decreased with increasing levels of succinic anhydride, but was still higher than untreated protein isolate. The oil absorption capacity is affected by several factors, such as the protein content, the surface area, the hydrophobicity, the charge and topography, the liquidity of the oil and the method used. Also, oil absorption capacity of protein may depend on its capacity to entrap the oil (Kinsella, 1976). Generally, the high oil absorption capacity of acylated mung bean protein isolate may be attributed to the degree of denaturation due to chemical modification. Succinylation and acetylation increased oil absorption capacity of rapeseed meals (Dua et al., 1996) and cottonseed flour (Choi et al., 1981) with increasing levels of acylation, while no change occurred up to 73% actylation in cottonseed flour (Rahma & Narasinga Rao, 1983). Beuchat (1977) found no marked changes in oil absorption capacity of peanut flour due to succinylation.

3.5. Foam capacity

The effect of succinylation and acetylation on foam capacity of mung bean protein isolate is shown in Fig. 6. The foam capacity was significantly increased ($P \leqslant 0.05$) due to increasing levels of acetylation and succinylation compared to untreated isolate. Foam capacity of acetylated protein isolate was higher than that of succinylated protein isolate. At a ratio of 1 g of acid anhydride/g of protein, the foam capacities were 135 and 129% for acetylated and succinylated protein isolates, respectively. Acylation increased the foam capacity of protein

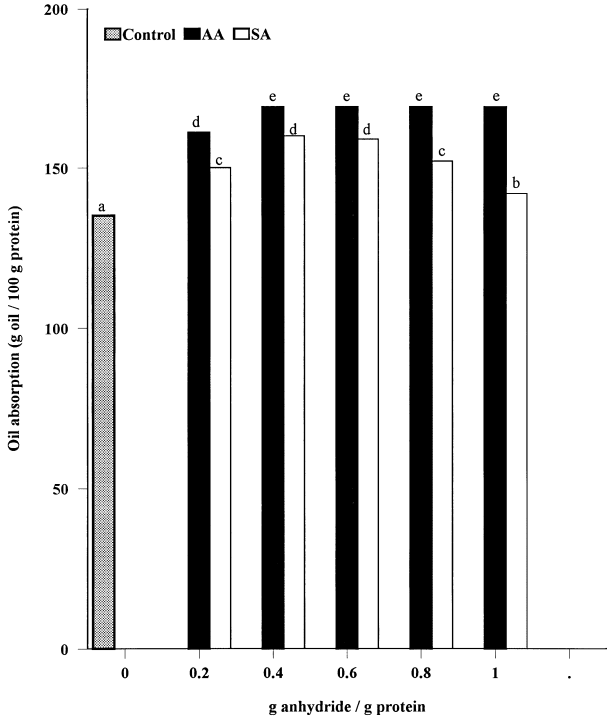

Fig. 5. Effects of various concentrations of acetic anhydride (AA) and succinic anhydride (SA) on oil absorption capacity of mung bean protein isolate. Values followed by the same letter are not significantly different ($P < 0.05$). Least significant difference (LSD) at 5% = 3.75.

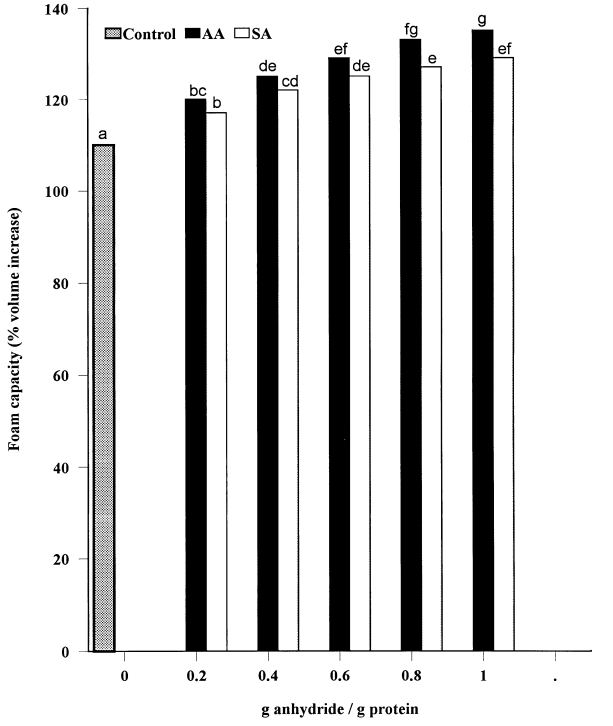

Fig. 6. Effects of various concentrations of acetic anhydride (AA) and succinic anhydride (SA) on foam capacity of mung bean protein isolate. Values followed by the same letter are not significantly different ($P < 0.05$). Least significant difference (LSD) at 5% = 3.61.

molecules because acetylation decreased the number of positive charges by substituting hydrophobic acetyl groups for the positively charged ε-amino groups. However, succinylation increased the negatively charged hydrophilic acyl groups on protein molecules. These observations agree well with those reported by Johnson and Brekke (1983) for acylated pea protein isolate and Dua et al. (1996) for acylated rapeseed meal.

3.6. Foam stability

The effect of acylation on foam stability of mung bean protein isolate is shown in Table 1. Foam stability increased significantly ($P \leqslant 0.05$) with increasing the levels of succinic and acetic anhydrides up to 0.4 g of acid anhydrides/g of protein, then significantly decreased ($P \leqslant 0.05$) compared to untreated protein isolate at all standing times. The foam stability of acylated mung bean protein isolate decreased markedly within the first 15 min and then decreased gradually; also it did not show any marked changes after 45 min. The foam stability of acetylated protein isolate was high compared to the succinylated protein isolate. Foam stability is reduced with acylation because of negative charges imparted during modification causing the protein molecule to unfold. Excessive modification leads to increased net charge density which prevents protein–protein interaction in the foam lamellae, causing foam destabilization and poor stability (Cheftel, Cuq & Lorient, 1985). Generally, our observation regarding the decrease in foam stability of acylated mung bean protein isolate agrees with the observation of Dua et al. (1996) for acylated rapeseed meal.

3.7. Emulsification properties

The emulsification properties of acylated mung bean protein isolate are shown in Table 2. Emulsification capacity was significantly increased ($P \leqslant 0.05$) due to acylation of mung bean protein isolate by acetic and succinic anhydrides. Also, emulsion stability increased significantly ($P \leqslant 0.05$) with increasing level of acetylation (up to 0.8 g anhydride/g of protein) and succinylation (up to 0.6 g acid anhydride/g of protein). However, the higher concentrations caused reduction of the emulsifying capacity and stability of the protein isolate. It is noteworthy that, even at the lowest reduction in emulsifying capacity and stability due to acylation, levels were still higher than that of the untreated protein isolate. Succinylated and acetylated protein isolates had the same trends of emulsifying capacity and stability at a ratio of 0.2 and 0.8 g acid anhydrides/g of protein. On the other hand, emulsification activity was significantly decreased ($P \leqslant 0.05$) over 0.6 g of succinic or acetic anhydrides/g protein. The observed increase in emulsifying properties of acylated protein isolate compared with untreated protein isolate due to acylation tends to cause unfolding of protein chains, thereby exposing hydrophilic residues of peptides (Feeny, Yamasaki & Geoghegen, 1982); this causes an improvement in emulsification properties of the protein. Also, the addition of carboxyl groups by succinylation aids in increasing the

Table 1
Effect of various concentration of acetic anhydride (AA) and succinic anhydride (SA) on the foam stability (ml) of mung bean protein isolate[a]

g anhydrides/g protein		Standing time (min)							
		15		30		45		60	
		Foam stability (ml)	Foam volume change (ml)	Foam stability (ml)	Foam volume change (ml)	Foam stability (ml)	Foam volume change (ml)	Foam stability (ml)	Foam volume change (ml)
	0.0	39e	–	28cd	–	26c	–	26c	–
AA									
	0.2	58i	+19	36g	+8	33e	+7	33e	+7
	0.4	50g	+11	33f	+5	29d	+3	28d	+2
	0.6	38e	−1	27bc	−1	24b	−2	24b	−2
	0.8	35cd	−4	26ab	−2	23ab	−3	23ab	−3
	1.0	33ab	−6	25a	−3	22a	−4	22a	−4
SA									
	0.2	53h	+14	30e	+2	29d	+3	28d	+2
	0.4	42f	+3	29de	+1	27c	+1	26c	0.0
	0.6	36d	−3	27bc	−1	24b	−2	24b	−2
	0.8	34bc	−5	25a	−3	22a	−4	22a	−2
	1.0	32a	−7	25a	−3	22a	−4	22a	−4
LSD[b]		1.44	–	1.02	–	1.02	–	1.14	–

[a] Means in the same column with different letters are significantly different ($P \leqslant 0.05$).
[b] LSD = least significant difference at 5%.

interaction between protein molecules and the aqueous phase of the emulsions.

3.8. Antinutritional factors

The changes in some antinutritional factors such as tannins, phytic acid and trypsin inhibitor due to acetylation and succinylation of mung bean protein isolate are shown in Table 3. Acylation significantly reduced ($P \leqslant 0.05$) the antinutritional factors found naturally in mung bean protein isolate. Acetylation was more effective for the reduction of antinutritional factors than was succinylation. Among the antinutritional factors, the highest reduction occurred in trypsin inhibitor followed by tannins and phytic acid, respectively. Generally, the decrease in antinutritional factors of acylated protein isolate may be due to the dialysis process against distilled water during the sample preparation. Also, the increase in negative charges, due to succinylation and introduction of bulky side groups due to acetylation, may affect the degree of protein–tannin interaction or protein–mineral–phytic acid interaction and hence

Table 2
Effect of various concentrations of acetic anhydride (AA) and succinic anhydride (SA) on the emulsification properties of mung bean protein isolate[a]

g anhydride/g protein		Emulsification capacity (ml oil/g protein)	Emulsification stability (%)	Emulsifying activity (%)
	0.0	245a	15a	65b
AA				
	0.2	267bc	18c	65b
	0.4	274cd	23e	64b
	0.6	274cd	21d	60b
	0.8	270c	17bc	45a
	1.0	266bc	16ab	36a
SA				
	0.2	267bc	18c	62b
	0.4	280de	21d	56b
	0.6	283e	21d	50b
	0.8	270c	16ab	42a
	1.0	260b	16ab	41a
LSD[b]	–	5.74	0.92	10.5

[a] Means in the same column with different letters are significantly different ($P \leqslant 0.05$).
[b] LSD = least significant difference at 5%.

Table 3
Effects of various concentrations of acetic anhydride (AA) and succinic anhydride (SA) on the antinutritional factors of mung bean protein isolate[a]

g anhydride/g protein		Tannins		Phytic acid		Trypsin inhibitor	
		mg/100 g Sample	% Reduction	mg/100 g Sample	% Reduction	TUI/mg protein	% Reduction
	0.0	152e	0.0	161h	0.0	6.12h	0.0
AA							
	0.2	129d	15.1	138f	14.3	3.75f	38.7
	0.4	120c	21.0	127de	21.1	3.06d	50.0
	0.6	111b	27.0	120cd	25.5	2.67c	56.4
	0.8	102a	32.9	111b	31.1	2.12b	65.4
	1.0	97a	36.2	102a	36.7	1.79a	70.8
SA							
	0.2	135d	11.2	149g	7.45	4.06g	33.7
	0.4	128d	15.8	133ef	17.4	3.42e	44.1
	0.6	120c	21.1	126de	21.7	3.02d	50.7
	0.8	116bc	23.7	121cd	24.9	2.86cd	53.3
	1.0	110b	27.6	117c	27.3	2.71c	55.7
LSD[b]		6.17	–	5.84	–	0.18	–

[a] Means in the same column with different letters are significantly different ($P < 0.05$).
[b] LSD = least significant difference at 5%.

decrease the tannin and phytic acid contents of modified mung bean protein isolate. Loomis (1974) reported that, during production of protein concentrates, quinone oxidation products of polyphenols may bind covalently with sulphydryl groups of cysteine and the ε-amino group of lysine as well as the ε-terminal amino groups of proteins. These observations are in agreement with those reported by Dua et al. (1996) for chemical modification of rapeseed meals.

3.9. In-vitro protein digestibility

Digestibility of succinylated and acetylated mung bean protein isolate, based on using trypsin-pancreatin, is shown in Fig. 7. The protein digestibility of protein isolate increased significantly ($P \leqslant 0.05$) with increasing levels of acetylation (up to 0.8 g anhydride/g protein) and succinylation (up to 0.4 g anhydride/g protein). Even at the highest levels of acetylation and succinylation, in-vitro protein digestibility was not changed significantly ($P \geqslant 0.05$) compared to untreated protein isolate. However, acetic anhydride was more effective in improving the protein digestibility than succinic anhydride. The increase in digestibility may be due to destruction of both trypsin inhibitor and tannins. Barroga, Laurena & Mendoza (1985) reported that the tannins play an important role in the reduction of protein digestibility. Another possibility may be that acylation causes dissociation and unfolding of protein molecules making them more susceptible to enzyme activity. The increase in in-vitro protein digestibility by acetylation has been reported by Johnson and Brekke (1983) for pea. However, Rahma and Narasinga Rao (1983) found no changes in in-vitro protein digestibility of cottonseed flour due to acylation.

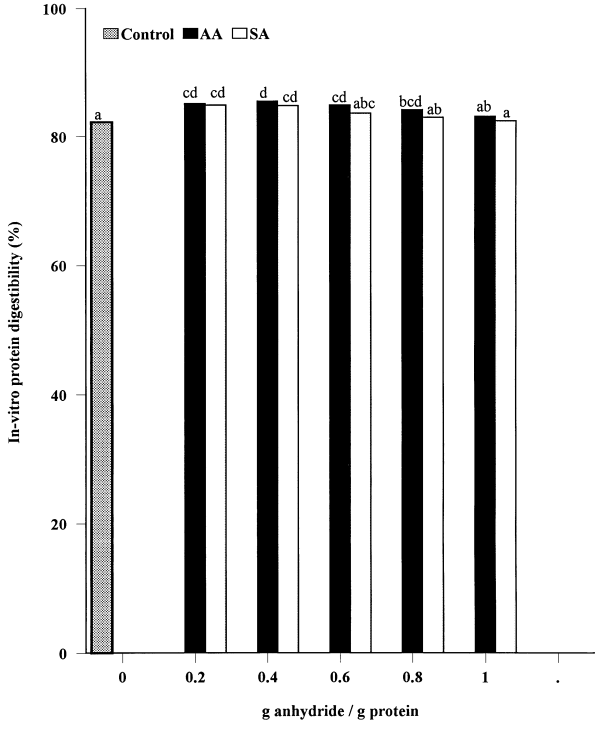

Fig. 7. Effects of various concentrations of acetic anhydride (AA) and succinic anhydride (SA) on in-vitro protein digestibility of mung bean protein isolate. Values followed by the same letter are not significantly different ($P < 0.05$). Least significant difference (LSD) at 5% = 1.14.

4. Conclusions

Acylated mung protein isolates were shown to be better than untreated protein isolate in protein solubility index, water and oil absorption capacities, foaming capacity and stability as well as emulsification capacity and stability. Acylation also reduced the antinutritional factors of protein isolate, which improved in-vitro protein digestibility. Generally, these results indicate that acetylated and succinylated mung bean protein isolates may be better than untreated protein isolate.

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