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Effect of Domestic Processing and Cooking Methods on the Contents of Carbohydrates of Amphidiploids (Black Gram x Mung Bean)

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ABSTRACT

The effects of soaking, ordinary and pressure cooking of soaked and unsoaked seeds and the effects of sprouting on sugar and starch contents of amphidiploid (black gram x Mung bean) seeds were investigated. Soaking reduced the level of total soluble sugars, reducing sugars, non-reducing sugars and starch significantly. Cooking (both ordinary and pressure cooking) increased the concentrations of sugars of soaked as well as unsoaked seeds; starch contents, however, decreased. Germination decreased starch, thereby raising the level of the soluble sugars.

INTRODUCTION

Food legumes are an important component of diet for the majority population in India and several other developing countries. Besides being an inexpensive source of protein, the pulses are suppliers of dietary calories in the form of carbohydrates.

Interspecific hybridization (amphidiploidy) has been considered an important tool to increase genotypic variability in food crops. Selection from a wide range of variability in desirable attributes of genotypes has resulted in the development of high yielding varieties of amphidiploids (Smartt & Haq, 1972).

Legume grains are processed and cooked in a variety of ways depending on taste and cultural preferences. Different processing and cooking

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treatments have been shown to affect the level of available carbohydrates in legume grains (Jood *et al.*, 1986, 1988; Kataria & Chauhan, 1988). This paper reports the effects of various domestic processing and cooking treatments, including soaking, cooking (ordinary and pressure cooking) and sprouting on the contents of available carbohydrates of some promising strains of amphidiploids (black gram × Mung bean) developed by Haryana Agricultural University, Hisar, India.

MATERIALS AND METHODS

Materials

Seed samples of four varieties of amphidiploids (T_1-12, T_1-19, T_2-10 and T_2-26) were obtained from the Department of Plant Breeding, Haryana Agricultural University, Hisar (India).

Processing and cooking methods

Methods of processing and cooking included soaking in water for different intervals of time, ordinary and pressure cooking of soaked as well as unsoaked seeds and sprouting of the seeds.

Soaking

Seeds freed from broken seeds, dust and other foreign materials were soaked in water for 6, 12 and 18 h at 37°C. A seed to water ratio of 1:5 (w/v) was used. The unimbibed water was discarded. The soaked seeds were washed twice with ordinary water followed by rinsing with distilled water and then dried in a hot air oven at 70°C to constant weight.

Cooking

Seeds, after soaking for 12 h, were rinsed in distilled water and put in round-mouthed tall beakers fitted with condensers. After adding distilled water (three times the weight of dry seeds), the samples were boiled until soft, as felt between fingers. Cooked seeds along with cooking water were dried to a constant weight at 70°C for 36 h. Unsoaked seeds were also cooked in the same manner, using a seed to water ratio of 1:7 (w/v). For pressure cooking, the seeds were autoclaved at 1·05 kg/cm^2 pressure for 5, 10 and 15 min. For this, a dry seed to water ratio of 1:2 (w/v) was used. The cooked samples were mashed and then dried at 70°C.

Germination

The seeds soaked for 12 h were germinated in sterile Petri-dishes lined with wet filter paper for 24, 36, 48 and 60 h at 25°C, with frequent watering. The sprouts were then dried at 70°C to a constant weight.

The oven-dried unprocessed as well as processed samples were milled in a cyclone mill (Cyclotec, Tecator, Sweden) to pass through 0·5 mm sieve and stored in plastic containers until required for further analysis.

Chemical analysis

Total soluble sugars were extracted by refluxing in 80% ethanol (Cerning & Guilbot, 1973) and starch from the sugar-free pellet was extracted in 52% perchloric acid at room temperature (Clegg, 1956). Soluble sugars and starch were determined colorimetrically (Yemm & Willis, 1954). Reducing sugars were estimated by Somogyi's modified method (Somogyi, 1945). Non-reducing sugars were determined as the difference between total soluble sugars and reducing sugars.

Statistical analysis

The data were processed for analysis of variance to find the significant differences among various treatments (Snedecor & Cochran, 1967).

RESULTS AND DISCUSSION

Soaking

Soaking of dry seeds of the amphidiploids reduced the level of total soluble sugars, reducing sugars, non-reducing sugars and starch significantly (Table 1). The extent of reduction increased with the increase in period of soaking. After 18 h of soaking the ranges of loss of total soluble sugars, reducing sugars, non-reducing sugars and starch were 28 to 33%, 31 to 38%, 27 to 33% and 8 to 11%, respectively. Losses of sugars during soaking could be due to simple diffusion of sugar after solubilization. The greater losses of the sugars during the longer periods of soaking may be due to enhanced solubility of sugars. The reducing effects of soaking on soluble carbohydrates in some pulses have been reported earlier (Silva & Braga, 1982; Jood *et al.*, 1986, 1988; Kataria & Chauhan, 1988).

Cooking

After soaking for 12 h the seeds were cooked until soft. By and large all the sugars showed an upward trend in their concentration after cooking (Table 2)

TABLE 1

Effect of Soaking on Total Soluble Sugars (g/100 g), Reducing Sugars (mg/100 g), Non-reducing Sugars (g/100 g) and Starch (g/100 g) of Amphidiploids (on dry matter basis)[a]

Carbohydrates	*Soaking period (h)*	*Varieties*			
		T_1-12	*T_1-19*	*T_2-10*	*T_2-26*
Total soluble sugars	0	7·8 ± 0·1	8·4 ± 0·2	7·6 ± 0·1	8·5 ± 0·1
	6	5·8 ± 0·0 (−25)	6·1 ± 0·0 (−28)	5·6 ± 0·0 (−27)	6·4 ± 0·1 (−24)
	12	5·6 ± 0·0 (−28)	5·9 ± 0·0 (−29)	5·4 ± 0·1 (−30)	6·3 ± 0·0 (−25)
	18	5·4 ± 0·0 (−30)	5·7 ± 0·0 (−32)	5·1 ± 0·1 (−33)	6·2 ± 0·1 (−28)
		CD ($P < 0·05$) = 0·2			
Reducing sugars	0	329 ± 20	311 ± 10	407 ± 10	438 ± 0
	6	277 ± 12 (−16)	257 ± 13 (−17)	319 ± 10 (−22)	394 ± 10 (−10)
	12	279 ± 10 (−15)	253 ± 16 (−19)	279 ± 14 (−32)	334 ± 10 (−24)
	18	205 ± 10 (−38)	198 ± 17 (−36)	251 ± 7 (−38)	303 ± 13 (−31)
		CD ($P < 0·05$) = 20			
Non-reducing sugars	0	7·4 ± 0·1	8·1 ± 0·2	7·2 ± 0·1	8·1 ± 0·1
	6	5·5 ± 0·0 (−26)	5·18 ± 0·0 (−28)	5·3 ± 0·0 (−27)	6·1 ± 0·1 (−25)
	12	5·3 ± 0·1 (−28)	5·7 ± 0·0 (−30)	5·1 ± 0·1 (−30)	6·1 ± 0·0 (−25)
	18	5·2 ± 0·0 (−29)	5·5 ± 0·0 (−32)	4·8 ± 0·4 (−33)	5·9 ± 0·1 (−27)
		CD ($P < 0·05$) = 0·2			
Starch	0	47·9 ± 0·3	45·6 ± 0·6	47·5 ± 1·1	44·0 ± 0·6
	6	46·6 ± 0·3 (−3)	43·9 ± 0·7 (−4)	45·3 ± 0·5 (−5)	42·7 ± 0·5 (−3)
	12	45·7 ± 0·1 (−5)	42·8 ± 0·6 (−6)	44·8 ± 0·1 (−6)	42·4 ± 0·3 (−4)
	18	44·3 ± 0·3 (−8)	41·0 ± 0·8 (−11)	43·4 ± 0·3 (−9)	40·0 ± 0·5 (−9)
		CD ($P < 0·05$) = 0·9			

[a] Values are means ± SD of four replicates. Figures in parentheses indicate decrease (−) or increase (+) expressed as percentage of control values.

but the values were still less than the control ones. A maximum was noticed in the case of reducing sugars which either reached, or were slightly less than, the control values. Cooking of unsoaked seeds of amphidiploids also raised the level of total soluble sugars, reducing sugars and non-reducing sugars. The increment appeared to be greater in reducing sugars (14–20%) than in total soluble sugars (9–11%) and non-reducing sugars (8–10%). The level of sugars in pressure-cooked samples of soaked seeds was found to be higher than either the control or the seeds soaked for 12 h and then cooked. There was a continuous increase in sugar content of seeds as the period of pressure cooking was raised from 5 to 15 min. The reducing sugars increased to a greater extent than total soluble sugars or non-reducing sugars. Pressure cooking of unsoaked seeds also increased the level of sugars and the margin of increase in total soluble sugars and non-reducing sugars was higher than that observed during pressure cooking of soaked seeds. On the other hand the starch content of the amphidiploids decreased when the soaked seeds were cooked; the extent of decrease ranged from 21 to 32%. An almost similar reduction in starch content was observed when unsoaked seeds were ordinarily cooked. Pressure cooking of soaked seeds for 5 min caused a considerable reduction in starch content of the amphidiploid seeds. There was a continuous decrease in the starch content of the seeds when the period of pressure cooking was further raised. A decrease of 46 to 59% was noticed after 15 min of pressure cooking. Pressure cooking of unsoaked seeds at the same pressure for 15 min decreased the starch contents to a smaller extent. The data indicate that the cooking methods increased reducing sugars to a greater extent than non-reducing sugars. Hydrolysis of starch to oligosaccharides and then to monosaccharides, as a consequence of moist heating, may be responsible for increased concentration of sugars in the cooked pulses. Increased levels of sugars in chickpea and black gram (Rao & Belavady, 1978; Jood *et al.*, 1988) and mung bean (Kararia & Chauhan, 1988) have previously been reported. Both ordinary and pressure cooking may cause rupturing of starch granules followed by hydrolysis of the starch. This may, perhaps, explain the decreasing starch content during cooking processes. A similar trend in starch content of the cooked legume seeds was observed by Jood *et al.* (1986), and Kataria and Chauhan (1988).

Germination

When the 12 h-soaked seeds were germinated, a gradual increase in concentration of sugars (total, reducing and non-reducing) with increase in germination time was noticed (Table 3). As a result of the 60 h germination, the level of reducing sugars was 8 to 35% higher than untreated control

TABLE 2

Effect of Cooking on Total Soluble Sugars (g/100 g), Reducing Sugars (mg/100 g), Non-reducing Sugars (g/100 g) and Starch (g/100 g) of the Amphidiploids (on dry matter basis)[a]

Carbohydrates	*Cooking method*	*Varieties*			
		T_1-12	*T_1-19*	*T_2-10*	*T_2-26*
Total soluble sugars	Ordinary cooking of soaked seeds	6·0 ± 0·1 (−23)	6·4 ± 0·1 (−24)	5·7 ± 0·0 (−25)	7·0 ± 0·1 (−17)
	Ordinary cooking of unsoaked seeds	8·6 ± 0·1 (+11)	9·2 ± 0·0 (+9)	8·3 ± 0·1 (+9)	9·3 ± 0·1 (−19)
	Pressure cooking of soaked seeds				
	5 min	8·5 ± 0·1 (+9)	8·9 ± 0·1 (+6)	8·3 ± 0·1 (+9)	9·1 ± 0·1 (+7)
	10 min	8·9 ± 0·1 (+14)	9·2 ± 0·1 (+10)	8·8 ± 0·0 (+15)	9·5 ± 0·1 (+11)
	15 min	9·4 ± 0·0 (+21)	9·6 ± 0·1 (+14)	9·3 ± 0·2 (+22)	9·9 ± 0·1 (+16)
	Pressure cooking of unsoaked seeds				
	15 min	9·4 ± 0·1 (+22)	9·8 ± 0·1 (+17)	9·5 ± 0·0 (+22)	8·7 ± 1·4 (+2)
		CD ($P < 0·05$) = 0·2			
Reducing sugars	Ordinary cooking of soaked seeds	331 ± 10 (+0·6)	308 ± 13 (+0·6)	371 ± 10 (−9)	407 ± 13 (−7)
	Ordinary cooking of unsoaked seeds	378 ± 23 (+15)	374 ± 11 (+20)	466 ± 6 (+14)	515 ± 11 (+17)
	Pressure cooking of soaked seeds				
	5 min	435 ± 51 (+32)	371 ± 10 (+19)	449 ± 13 (+10)	487 ± 13 (+11)
	10 min	453 ± 16 (+38)	430 ± 12 (+38)	518 ± 15 (+27)	492 ± 10 (+11)
	15 min	490 ± 17 (+50)	521 ± 10 (+68)	570 ± 11 (+40)	574 ± 50 (+31)
	Pressure cooking of unsoaked seeds				
	15 min	525 ± 16 (+60)	490 ± 4 (+58)	545 ± 13 (+34)	573 ± 23 (+31)
		CD ($P < 0·05$) = 20			

TABLE 2—*contd.*

Carbohydrates	*Cooking method*	*Varieties*			
		T_1-12	*T_1-19*	*T_2-10*	*T_2-26*
Non-reducing sugars	Ordinary cooking of soaked seeds	5·6 ± 0·1 (−24)	6·1 ± 0·1 (−25)	5·3 ± 0·0 (−26)	6·6 ± 0·1 (−18)
	Ordinary cooking of unsoaked seeds	8·2 ± 0·2 (+10)	8·8 ± 0·0 (+9)	7·9 ± 0·1 (+9)	8·7 ± 0·1 (+8)
	Pressure cooking of soaked seeds				
	5 min	8·2 ± 0·3 (+11)	8·4 ± 0·3 (+4)	7·9 ± 0·1 (+9)	8·6 ± 0·1 (+7)
	10 min	8·4 ± 0·1 (+13)	8·8 ± 0·1 (+9)	8·3 ± 0·0 (+14)	8·9 ± 0·1 (+11)
	15 min	8·9 ± 0·0 (+19)	9·1 ± 0·1 (+12)	8·8 ± 0·1 (+21)	9·3 ± 0·0 (+15)
	Pressure cooking of unsoaked seeds				
	15 min	8·9 ± 0·1 (+20)	9·3 ± 0·1 (+15)	8·9 ± 0·0 (+24)	8·1 ± 1·4 (+8)
		CD ($P < 0·05$) = 0·2			
Starch	Ordinary cooking of soaked seeds	37·7 ± 0·2 (−21)	34·6 ± 0·3 (−24)	32·3 ± 0·6 (−32)	30·7 ± 0·7 (−30)
	Ordinary cooking of unsoaked seeds	38·0 ± 0·3 (−21)	35·6 ± 0·4 (−22)	33·4 ± 0·3 (−30)	32·1 ± 0·2 (−27)
	Pressure cooking of soaked seeds				
	5 min	39·4 ± 5·7 (−18)	32·8 ± 0·7 (−28)	31·5 ± 1·0 (−34)	29·4 ± 0·3 (−33)
	10 min	33·8 ± 2·8 (−29)	29·6 ± 0·4 (−35)	27·4 ± 0·4 (−42)	24·9 ± 2·5 (−43)
	15 min	25·8 ± 0·4 (−46)	24·6 ± 0·8 (−46)	19·7 ± 1·6 (−58)	17·9 ± 1·4 (−59)
	Pressure cooking of unsoaked seeds				
	15 min	28·6 ± 0·7 (−40)	27·2 ± 1·0 (−40)	24·4 ± 0·4 (−49)	23·0 ± 0·4 (−48)
		CD ($P < 0·05$) = 0·9			

[a] Values are means ± SD of four replicates. Figures in parentheses indicate decrease (−) or increase (+) expressed as percentage of control values.

TABLE 3

Effect of Germination on Total Soluble Sugars (g/100 g), Reducing Sugars (mg/100 g), Non-reducing Sugars (g/100 g) and Starch (g/100 g) of Amphidiploids (on dry matter basis)[a]

Carbohydrates	*Germination period (h)*	*Varieties*			
		T_1-*12*	T_1-*19*	T_2-*10*	T_2-*26*
Total soluble sugars	24	5·8 ± 0·1 (−26)	6·0 ± 0·1 (−28)	5·6 ± 0·0 (−26)	6·6 ± 0·1 (−22)
	36	5·9 ± 0·1 (−24)	6·3 ± 0·1 (−25)	5·9 ± 0·2 (−23)	6·8 ± 0·1 (−20)
	48	6·1 ± 0·1 (−21)	6·5 ± 0·1 (−23)	6·1 ± 0·0 (−21)	7·3 ± 0·6 (−14)
	60	6·4 ± 0·2 (−18)	6·7 ± 0·1 (−20)	6·4 ± 0·1 (−17)	7·7 ± 0·1 (−10)
		CD ($P < 0·05$) = 0·2			
Reducing sugars	24	313 ± 10 (−5)	302 ± 20 (−3)	358 ± 10 (−12)	422 ± 10 (−4)
	36	328 ± 13 (−1)	323 ± 6 (−0·5)	394 ± 10 (−3)	453 ± 12 (−3)
	48	384 ± 15 (+17)	363 ± 10 (+14)	424 ± 10 (+4)	478 ± 11 (+4)
	60	423 ± 26 (+28)	421 ± 10 (+35)	439 ± 12 (+8)	493 ± 15 (+13)
		CD ($P < 0·05$) = 20			
Non-reducing sugars	24	5·4 ± 0·1 (−27)	5·7 ± 0·2 (−29)	5·3 ± 0·0 (−27)	6·2 ± 0·1 (−23)
	36	5·6 ± 0·0 (−25)	5·7 ± 0·1 (−29)	5·5 ± 0·1 (−24)	6·4 ± 0·1 (−21)
	48	5·7 ± 0·1 (−23)	6·1 ± 0·1 (−25)	5·7 ± 0·1 (−22)	6·8 ± 0·1 (−16)
	60	5·9 ± 0·1 (−20)	6·3 ± 0·1 (−22)	5·9 ± 0·1 (−18)	7·2 ± 0·1 (−11)
		CD ($P < 0·05$) = 0·2			
Starch	24	37·8 ± 0·8 (−21)	35·6 ± 0·3 (−22)	38·6 ± 0·4 (−19)	34·7 ± 0·5 (−21)
	36	35·1 ± 0·3 (−27)	33·5 ± 0·2 (−26)	36·0 ± 0·4 (−24)	31·7 ± 0·3 (−28)
	48	33·8 ± 0·3 (−30)	32·2 ± 0·3 (−29)	34·9 ± 0·4 (−27)	30·8 ± 2·5 (−30)
	60	32·3 ± 0·5 (−33)	30·8 ± 0·4 (−32)	32·3 ± 0·2 (−32)	27·5 ± 0·4 (−37)
		CD ($P < 0·05$) = 0·9			

[a] Values are means ± SD of four replicates. Figures in parentheses indicate decrease (−) or increase (+) expressed as percentage of control values.

values but both total soluble and non-reducing sugar contents were still less than those of unprocessed seeds. On the other hand, the starch content of the amphidiploids decreased by 19 to 22% after 24 h germination. The decrease was continuously higher when the germination period was further extended to 36, 48 and 60 h. After 60 h germination the seeds contained less starch (less 32 to 37%) when compared with control values. Mobilization and hydrolysis of seed polysaccharides during germination may account for increased sugar content of germinated seeds (Kumar & Venkataraman, 1976; Subbulakshmi *et al.*, 1976) as reported in chickpea, blackgram (Jood *et al.*, 1988) and mung bean (Kararia & Chauhan, 1988). Starch of legume seeds is known to be hydrolyzed to oligosaccharides and ultimately to monosaccharides during germination. Monosaccharides are then utilized for the production of energy required for various metabolic processes during germination. This amylolysis, catalyzed by phosphorylase and amylases, is probably responsible for the decreased amount of starch in the legume sprouts. The decreased level of starch in various legume sprouts has been reported earlier (Kumar & Venkataraman, 1976; Sharma & Pant, 1979; Kataria & Chuahan, 1988).

The levels of sugars as well as starch in amphidiploids were reduced to a significant extent after soaking, sugars being reduced rather more. The levels of sugars in the seeds increased during cooking (both ordinary and pressure cooking) while the starch content decreased. Germination lowered starch and raised the sugar content.

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