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AMINO ACIDS CONTENT IN FROZEN BROAD BEAN DEPENDING ON CULTIVAR AND BEAN RIPENESS

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Key words: broad bean, cultivar, broad bean, degree of ripeness, frozen foodstuffs, amino acids composition

The content of amino acids was determined in cooked frozen broad beans of Windsor White, Hangdown White and Hangdown Green varieties with original dry matter contents of 20, 27 and 34%.

INTRODUCTION

One of the paramount problems in food production is the acquisition of new and more rational utilization of existing sources of protein. A phenomenon raising concern in Poland is the decreasing consumption of pulses in times when the cost of producing food, especially that of producing animal protein, is mounting steadily [13, 20]. Pulses are universally regarded as a rich source of valuable vegetable protein [4, 8, 9, 18]. Kulka [7] reports that the amino acid composition of pulse protein resembles that of full-value animal protein. Compared with cereal gram, pulses contain almost twice as much lysine, but less methionine. Ewans [1], Lattanzio [9] and Palmer [14] include methionine, cystine and sometimes also valine and tryptophan among amino acids present in pulses in insufficient quantities.

According to Szyrmer [20] the per capita annual consumption of pulses in Poland in the 1960s was 4-6 kg. Today the figure stands at a mere 1 kg, and this is less than in Yugoslavia, France, Italy or Sweden, countries with a similar diet.

Plans are being drawn up to boost the consumption of pulses in Poland to 3 kg per head per year [20]. A significant role here may be played by the consumption of broad beans in the form of organoleptically attractive canned and frozen dishes [10, 11].

The objective of this research was the determination of amino acids contents in frozen broad beans of varieties available in Poland, with dry matter contents in fresh beans ranging from 20 to 34%.

MATERIAL AND METHODS

The analyses were performed with frozen broad beans stored for six months at −20°C and then cooked to an edible form. Three cultivars were used in the experiments: Windsor White, Hangdown White and Hangdown Green, in three stages of ripeness reflected by dry matter contents in the beans of 20, 27 and 34%. The freezing process was as follows: After shelling, the broad beans were sorted, washed, and blanched in water at 96-98°C for 2.5, 3.0 and 3.5 min, depending on their ripeness. The beans were then cooled for 3 min in a cold water stream, dried on sieves, placed on trays (ca. 3 cm layers) and frozen in a Feutron 3101-01 air washer with active air circulation at −35°C. Bean temperature dropped to −20°C after 30 min, following which the beans were packed in polyethylene bags (0.04 mm thick) and transferred to a cold room.

The material to be analysed was lyophilized, and amino acids (with the exception of tryptophan) were determined by ion exchange column chromatography after preliminary acid hydrolysis, according to Moore's method [12] modified by Spackman [19] with a Carlo Erba 3 A 27 automatic amino acid analyzer. Hydrolysis was done with 6 n HCl for 22 h at 110°C. Prior to hydrolysis, the samples for sulphuric amino acids determination were subjected to preliminary oxidation with performic acid to cysteic acid and methionine sulfone by the method recommended by Moore [12]. The results of parallel determinations did not differ by more than 2%.

The CS index was determined for each essential amino acid according to the method of Mitchell and Block; for total essential amino acids there was calculated the EAA index according to Oser, with reference to the amino acid level in the hen egg standard quoted in the 1985 FAO/WHO report.

RESULTS

It was found that 100 g portions of cooked frozen broad bean of the three analysed varieties contained similar amounts of amino acids: 6444-6587 mg (mean figures three ripeness stages; Table 1). The various cultivars also displayed similar contents of essential amino acids, ranging from 2456 mg in 100 g of cooked frozen Windsor White beans to 2525 mg in the Hangdown Green sample. The only sizeable differences, in excess of 8%, observed in the cultivars concerned the contents of arginine and proline.

In contrast, large differences in amino acids contents were apparent when the various ripeness stages were compared. The higher the dry matter content in the raw material to be frozen, the greater the content of amino acids. 100 mg of ready-to-eat cooked frozen beans that were least ripe contained 4404 mg of total amino acids and 1653 essential amino acids; in moderately ripe beans the respective figures were 6748 and 2588 mg, and in the ripest beans — 8699 and 3341 mg (mean figures for all three cultivars).

The quality of the protein of cooked frozen beans is illustrated by figures in Table 2 and in Figs 1 and 2. Statistical analysis shows that the contents of amino acids (with the exception of treonine) converted to 1 g nitrogen differed significantly in the individual cultivars and ripeness stages (Table 2). Despite the statistical differences in individual amino acids contents, the frozen beans of all three varieties had similar total amino acids contents — ranging from 5972 to 6049 mg/g N — and of essential amino acids — 2265-2316 mg/g N (mean figures for three stages of ripeness).

Table 1. Amino acids content following acid hydrolysis in frozen broad beans of three cultivars in various stages of ripeness (in mg per 100 g fresh mass)

Amino acid	Cultivar								
	Windsor White			Hangdown White			Hangdown Green		
	I	II	III	I	II	III	I	II	III
Lysine	310	572	644	329	492	646	362	487	587
Histidine	111	195	245	112	180	215	126	175	249
Arginine	509	790	900	484	567	802	549	744	771
Treoning	161	263	270	167	229	337	176	250	329
Aspartic acid	610	922	956	599	777	1073	583	793	1091
Serine	189	342	424	198	313	446	214	330	451
Glutamic acid	672	1360	1619	690	1206	1690	716	1226	1725
Proline	165	294	399	198	259	359	169	177	357
Glycine	175	306	394	172	278	407	193	291	404
Alanine	261	347	301	262	310	387	296	313	379
Cystine	47	89	112	48	93	122	52	78	121
Valine	214	344	402	217	317	443	232	327	444
Methionine	51	73	73	45	63	78	58	58	75
Isoleucine	184	289	399	188	280	396	191	286	404
Leucine	321	542	663	318	506	727	332	533	746
Tyrosine	136	271	214	136	219	303	146	223	311
Phenyloalanine	177	289	368	179	285	402	176	296	410
Essential amino acids*)	1601	2734	3146	1626	2485	3453	1725	2538	3428
Total	4294	7391	8384	4340	6374	8827	4568	6588	8855

Dry matter content in fresh beans I — ca 20%, II — ca 27%, III — ca 34%
*) Without tryptophan

The total and essential amino acids contents tended to rise with increasing ripeness degree, with the latter rising more than the former. The quantities of histidine, serine, glutamic acid, glycine, cystine, valine, isoleucine, leucine, and phenylalanine increased systematically, while those of arginine, aspartic acid, alanine, and methionine dropped. No regularities were observed in the case of lysine, treonine, proline and tyrosine.

The protein of cooked frozen broad beans was exceptionally rich in lysine (CS of 104-127). The amounts of leucine, phenylalanine with tyrosine, treonine, valine and isoleucine were below optimal when compared with the respective amounts in the standard protein: in our experiments the CS figures were 73-96, 64-82, 61-77, 61-71, and 58-70, respectively. The nain amino acids decreasing the quality of the analysed protein were methionine with cystine; their CS index ranged from 34 to 46 (Fig. 1).

The integrated index of essential amino acids EAA ranged from 63 to 74 depending on the cultivant and the ripeness stage. It tended to rise with increasing ripeness in the Hangdown White and Hangdown Green varieties. In the case of Windsor White this index was highest (72) in the moderately ripe beans.

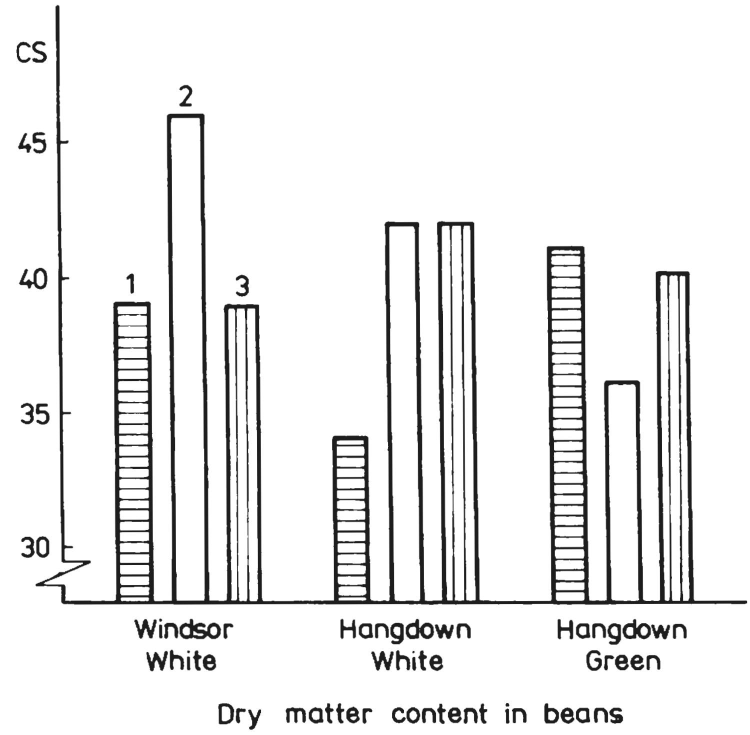

Fig. 1. Limiting amino acids index (methionine with cystine) for protein of cooked frozen broad beans depending on cultivar and bean ripeness; 1 — 20%, 2 — 27%, 3 — 34%

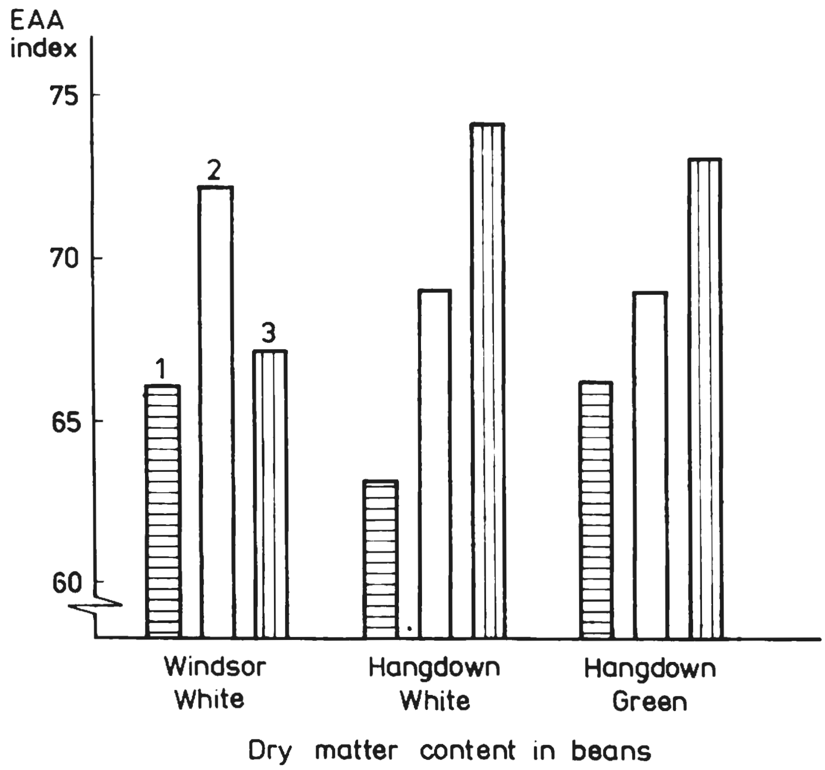

Fig. 2. EAA index for protein of cooked frozen broad beans depending on cultivar and bean ripeness (without tryptophan); 1 — 20%, 2 — 27%, 3 — 34%

Table 2. Amino acids content following acid hydrolysis in frozen broad beans of three cultivars in various stages of ripeness (in mg per 1 g N)

Amino acid	Cultivar									LSD p = 0.01	
	Windsor White			Hangdown White			Hangdown Green			a	b
	I	II	III	I	II	III	I	II	III		
Lysine	422	511	462	419	455	471	468	444	420	13.3	23.1
Histidine	150	174	175	143	166	157	162	159	178	9.0	15.6
Arginine	691	706	645	617	524	584	710	678	551	16.9	29.3
Treonine	219	235	194	213	212	246	228	227	236	$F_{emp.} < F_t$	$F_{emp.} < F_t$
Aspartic acid	829	823	686	764	719	782	754	724	780	14.7	25.5
Serine	257	305	305	252	289	325	276	300	322	9.2	15.9
Glutamic acid	913	1215	1162	880	1116	1232	926	1117	1235	13.7	23.7
Proline	224	262	286	252	240	261	218	161	256	9.0	15.6
Glycine	238	274	282	220	257	293	250	265	289	7.7	$F_{emp.} < F_t$
Alanine	355	310	216	334	287	282	383	285	271	8.8	16.1
Cystine	64	79	81	62	86	89	68	71	87	1.9	3.3
Valine	291	308	288	277	294	323	301	298	318	4.3	7.4
Methionine	69	66	52	57	58	57	75	53	53	0.9	1.7
Isoleucine	250	258	286	239	259	289	247	261	289	3.3	$F_{emp.} < F_t$
Leucine	436	484	476	406	468	530	429	486	534	10.5	18.2
Tyrosine	184	242	153	173	203	221	189	203	222	6.5	11.3
Phenyloalanine	241	258	264	228	263	293	228	269	294	6.1	10.5
Essential amino acids*)	2176	2441	2256	2074	2298	2519	2233	2312	2453	13.3	23.0
Total	5833	6510	6013	5536	5896	6435	5912	6001	6335	30.4	52.6

Dry matter content in fresh beans: I — ca 20%, II — ca 27%, III — ca 34%

a — for cultivars and degree of bean ripeness, b — for interaction

*) without tryptophan

DISCUSSION

The publications concerning amino acid content in untreated and processed broad beans are fairly numerous [2, 3, 9, 16, 17] but all the reported studies were performed with physiologically mature beans. Similarly as in the case of fully ripe beans [2, 3, 5, 6, 9, 14] the amino acids which adversely affect the biological quality of protein of broad bean in the milk stage of ripeness were chiefly methionine with cystine, and the amino acid present in excessive quantities was lysine [5]. Cooked frozen broad beans in the milk stage of ripeness (especially those containing 34% dry matter), similarly as products from physiologically mature beans, had fairly high contents of leucine and of phenylalanine with tyrosine compared with the respective contents in standard protein [3, 14].

A diet combining the lysine-rich broad beans with cereal products which are lysine-poor [7, 15, 22, 23] might lead to a better utilization of protein by the human organism.

If Williams' [21] estimates of essential amino acids requirements are correct, 100 g of cooked frozen broad beans with ca. 34% dry matter content (mean figure for the three considered cultivars) provide 115% (women) and 78% (men) of the required daily intake of lysine; the respective figures for treonine are 83 and 62%, for valine — 69 and 54%, for isoleucine — 73 and 57%, for leucine — 98 and 65%, for methionine with cystine — 28 and 19%, and for phenylalanine with tyrosine — 95 and 61%.

CONCLUSIONS

1. The content of amino acids expressed in mg per 100 g of edible parts of cooked frozen broad beans depended only slightly on bean variety, but visibly increased with increasing ripeness of the raw material.

2. The content of amino acids expressed in mg per 1 g N differed in a statistically significant manner depending on the cultivar and the stage of ripeness, but the differences between cultivars were insignificant from the practical point of view.

3. As a rule, the limiting amino acid index CS increased with the increase of bean ripeness. The CS value in the case of lysine exceeded 100 regardless of the stage of ripeness. The amino acids having a particularly adverse effect of broad bean protein quality were methionine with cystine (CS amounting to 34-46).

4. The integrated essential amino acid index EAA ranged from 63 to 74. In the Hangdown White and Hangdown Green cultivars it was highest in the ripest beans, while in the Windsor White cultivar in the moderately ripe beans.

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ZAWARTOŚĆ AMINOKWASÓW W MROŻONKACH Z BOBU W ZALEŻNOŚCI OD ODMIANY I STOPNIA DOJRZAŁOŚCI NASION

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S t r e s z c z e n i e

Nasiona bobu odmiany Windsor Biały, Hangdown Biały i Hangdown Zielony o zawartości suchej masy na poziomie 20%, 27% i 34% zamrożono. Mrożonkę przechowywano przez 6 miesięcy, a następnie ugotowano. W produkcie przygotowanym do spożycia oznaczono zawartość aminokwasów. Ilość aminokwasów wyrażono w mg/100 g części jadalnych oraz w mg/1 g N. Ponadto obliczono wskaźnik CS i indeks EAA. Zawartość aminokwasów w ugotowanych mrożonkach z badanych odmian była bardzo podobna. Wykazano natomiast, że wraz z postępującą dojrzałością nasion ilość aminokwasów ulegała zwiększeniu, a jakość białka z reguły polepszeniu. Aminokwasami ograniczającymi jakość białka były metionina z cystyną (wartość CS 34 do 46). Indeks EAA wahał się w granicach od 63 do 74.