A Research Note

Amino Acid Composition and Its Change in Raw and Granulated Potatoes During Processing

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ABSTRACT

Total amino acids and composition of raw and cooked tubers were determined by gas-liquid and ion-exchange column chromatography. Peeled raw potato, after reaching the end product state, lost 40% of its free amino acid pool. Processing into dehydrated granules by the freeze-thaw process caused only small losses in total amino acids and little change in their composition. There was only a 4.5% destruction of essential amino acids and a total loss of 2.1% of non-essential amino acids, excluding aspartic and glutamic acids which comprised 48% of peeled and sliced potatoes.

INTRODUCTION

THE EFFECTS of peeling and cooking on the amino acids of potatoes has been examined earlier (Augustin et al., 1979; Davies, 1977; Davies and Thomas, 1973; Eppendorfer et al., 1979; Fitzpatrick et al., 1964; Kozempel et al., 1982; Talley and Porter, 1968; Talley et al., 1970, 1983; Toma et al., 1978; Yamagata, 1983). The losses in amino acids of dehydrated granulated potatoes prepared by the freeze-thaw process were investigated in this study.

MATERIALS & METHODS

APPROXIMATELY 4.3 kg medium-size potato tubers (Solanum tuberosum, cv. Russet Burbank) grown in Alberta and obtained from I & S Produce Ltd. (Edmonton) were washed, peeled and sliced.

Granule preparation by the freeze-thaw (F-T) process developed by Ooraikul (1977) was used for the preparation of dehydrated potato granules. Samples were withdrawn from each stage indicated by an asterick in Fig. 1 and then freeze-dried.

In order to follow the extent of destruction of labile amino acids (half-cystine, methionine, tryptophan and tyrosine), three different hydrolytic procedures (hydrolysis with HCL with a preliminary oxidation step (Blackburn, 1978); HCL without preliminary oxidation (Yamagata, 1983); and with methanesulfonic acid) were used for comparison studies for each sample (Liu and Chang, 1971; Simpson et al., 1976). Raw and processed potatoes were analyzed for amino acids by ion-exchange column chromatography (Blackburn, 1978; Moore et al., 1958; Moore and Stein, 1954; Rosen, 1957; Spackman et al., 1958; Synge, 1977) and simultaneously gas-liquid chromatography (GLC), (Golan-Goldhirsh and Wolfe, 1979; Golan-Goldhirsch et al., 1982; Kirkman et al., 1980; Tajima et al., 1978).

In this study all statistical data were determined by Duncan's (1955) Multiple Range Test.

RESULTS & DISCUSSION

THE AMINO ACID COMPOSITION of dehydrated potato granules obtained by a semi-pilot scale freeze-thaw process is given in Table 1. The data were obtained by applying gas-liquid and ion-exchange chromatography methods and were arranged by the unit operations of the process.

As revealed by GLC, the peeled tuber contained 90 mg of apparent amino acids/g dry potato. However, when the amino acids half-cystine, serine, isoleucine, leucine and histidine were included, the total amino acid content was raised to 104.5 mg/g dry potato. This decreased ($p < 0.05$) to 90.1 units after steam-cooking, 75.7 units after mashing, 74.2 units after freeze-thawing and 73.7 after granulation. Then end product content was 58.3 units and the discard, 71.6 units.

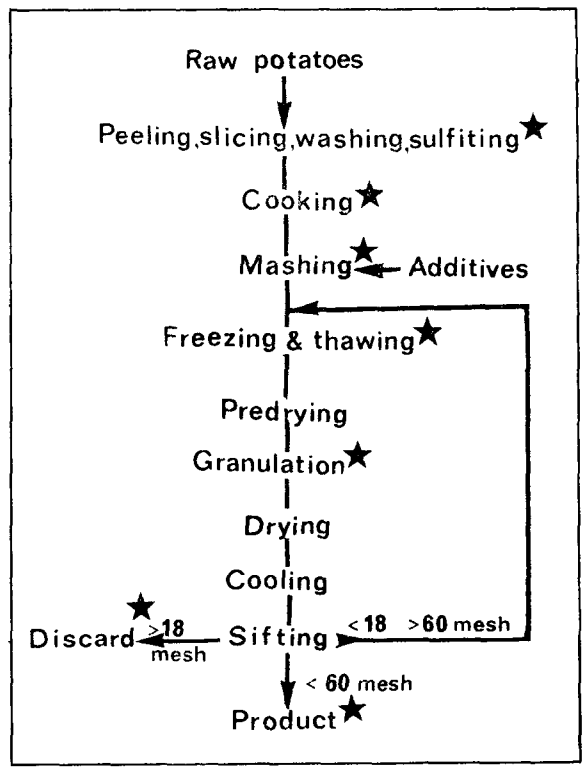

Fig. 1—Flow chart of the freeze-thaw process.

When ion-exchange chromatography data were analyzed, sliced samples provided 101.1 mg/g dry potato. This decreased ($p < 0.005$) to 92.6 units after steam-cooking, 91.6 units after mashing, 90.7 units after freeze-thawing and 85.6 units after granulation. The end product content was 84.5 units.

Total amino acids as found by GLC were either too low or the results obtained by ion-exchange chromatography were inflated (even though in the latter case the contents of Y-aminobutyric acid and ornithine were not included). The discrepancy between the two methods was tolerable only in slicing and steam-cooking steps but was too high in other steps (15.9 mg amino acid/g dry potato in mashing; 16.5 mg amino acid/g dry potato in freeze-thawing; 11.9 mg amino acid/g dry potato in granulation and 26.2 mg amino acid/g dry potato in end product.)

To resolve the discrepancy, the total crude protein-N content was followed during the granule process. The results (Table 1) revealed a steam-cook-induced loss of 4.6%, the loss ($p < 0.05$) increasing by 1.5% in mashing, 0.5% in freeze-thawing and 5.18% in granulation, giving a total loss of 11.78% total crude protein-N. The significant increase ($p < 0.05$) in the end product was only 1.1%. These results supported the ion-

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Table 1—Total amino acid composition of peeled potato tubers cv Russet Burbank (Alberta) processed into dehydrated freeze-thaw granules, using ion-exchange and gas-liquid chromatography methods

Amino acid		Amino acid content mg/g dry potato[a] freeze-thaw processing step						
		Slicing	Steaming	Hot mashing	Thawing	Granulation	End product	Discard portion
Aspartic acid	a[b]	28.32 ± 0.28	26.14 ± 0.24	26.39 ± 0.31	27.31 ± 0.45	22.28 ± 0.33	21.79 ± 0.36	24.26 ± 0.40
	b	28.19 ± 0.34	20.07 ± 0.34	19.06 ± 0.37	18.87 ± 0.34	18.82 ± 0.42	17.99 ± 0.41	19.26 ± 0.39
Threonine[c]	a	3.49 ± 0.47	3.23 ± 0.57	3.18 ± 0.41	3.07 ± 0.39	3.05 ± 0.47	3.01 ± 0.48	2.79 ± 0.54
	b	2.98 ± 0.65	2.80 ± 0.71	2.56 ± 0.49	2.54 ± 0.37	0.90 ± 0.38	2.16 ± 0.55	2.21 ± 0.47
Serine	a	3.49 ± 0.81	3.42 ± 0.60	3.15 ± 0.74	3.31 ± 0.44	2.99 ± 0.42	2.95 ± 0.52	2.75 ± 0.51
	b	–	–	–	–	–	–	–
Glutamic acid	a	19.79 ± 0.39	16.42 ± 0.41	17.41 ± 0.39	16.47 ± 0.37	16.61 ± 0.34	16.46 ± 0.33	15.56 ± 0.39
	b	17.34 ± 0.36	18.18 ± 0.30	14.21 ± 0.39	14.07 ± 0.31	14.28 ± 0.36	14.00 ± 0.36	14.52 ± 0.40
Proline	a	3.03 ± 0.42	2.56 ± 0.39	2.72 ± 0.27	2.25 ± 0.29	2.61 ± 0.35	2.56 ± 0.33	2.06 ± 0.36
	b	3.13 ± 0.34	3.10 ± 0.34	1.84 ± 0.37	1.82 ± 0.24	2.38 ± 0.29	1.53 ± 0.27	1.70 ± 0.22
Glycine	a	3.07 ± 0.51	2.77 ± 0.47	2.94 ± 0.42	2.86 ± 0.42	2.47 ± 0.33	2.49 ± 0.39	2.19 ± 0.37
	b	3.21 ± 0.44	2.88 ± 0.46	2.80 ± 0.41	2.77 ± 0.39	1.66 ± 0.37	1.66 ± 0.41	2.13 ± 0.42
Alanine	a	3.13 ± 0.36	2.90 ± 0.40	2.65 ± 0.37	2.69 ± 0.38	2.62 ± 0.39	2.55 ± 0.40	2.41 ± 0.31
	b	3.23 ± 0.39	2.74 ± 0.31	2.56 ± 0.36	2.55 ± 0.33	1.98 ± 0.30	1.97 ± 0.31	2.23 ± 0.31
1/2 Cystine[c]	a	1.08 ± 0.24	0.86 ± 0.26	0.92 ± 0.19	0.43 ± 0.21	1.03 ± 0.24	1.08 ± 0.29	0.81 ± 0.21
	b	–	–	–	–	–	–	–
Valine[c]	a	5.18 ± 0.69	4.91 ± 0.44	4.79 ± 0.46	4.66 ± 0.31	4.58 ± 0.47	4.52 ± 0.50	4.32 ± 0.34
	b	3.79 ± 0.55	4.49 ± 0.50	4.29 ± 0.43	4.25 ± 0.42	1.86 ± 0.42	2.84 ± 0.37	4.12 ± 0.36
Methionine[c]	a	1.06 ± 0.29	1.29 ± 0.24	0.96 ± 0.20	1.30 ± 0.24	1.19 ± 0.22	1.21 ± 0.21	1.27 ± 0.25
	b	4.69 ± 0.39	0.66 ± 0.22	0.73 ± 0.21	0.72 ± 0.19	1.36 ± 0.26	0.88 ± 0.24	0.91 ± 0.20
Isoleucine[c]	a	3.32 ± 0.34	3.08 ± 0.30	2.98 ± 0.31	2.99 ± 0.33	2.82 ± 0.29	2.79 ± 0.34	2.69 ± 0.31
	b	–	–	–	–	–	–	–
Leucine[c]	a	5.16 ± 0.77	4.78 ± 0.69	4.53 ± 0.62	4.42 ± 0.57	4.36 ± 0.49	4.31 ± 0.48	4.02 ± 0.47
	b	–	–	–	–	–	–	–
Tyrosine[c]	a	4.12 ± 0.44	4.13 ± 0.42	3.87 ± 0.40	4.01 ± 0.42	3.94 ± 0.41	3.88 ± 0.39	3.62 ± 0.38
	b	4.88 ± 0.39	4.99 ± 0.42	3.44 ± 0.43	2.97 ± 0.37	4.67 ± 0.47	3.25 ± 0.33	3.17 ± 0.37
Phenylalanine[c]	a	4.02 ± 0.34	3.64 ± 0.36	3.51 ± 0.33	3.59 ± 0.34	3.40 ± 0.34	3.33 ± 0.33	3.16 ± 0.31
	b	4.89 ± 0.40	2.75 ± 0.37	2.06 ± 0.29	2.04 ± 0.30	4.44 ± 0.39	2.22 ± 0.27	2.11 ± 0.27
Lysine[c]	a	5.57 ± 0.31	5.51 ± 0.31	5.08 ± 0.33	4.78 ± 0.40	4.92 ± 0.29	4.99 ± 0.31	4.40 ± 0.36
	b	4.36 ± 0.29	2.82 ± 0.28	3.09 ± 0.27	3.06 ± 0.23	2.01 ± 0.27	2.49 ± 0.28	2.79 ± 0.30
Histidine[c]	a	1.93 ± 0.30	1.92 ± 0.28	1.77 ± 0.29	1.68 ± 0.29	1.71 ± 0.23	1.68 ± 0.30	1.49 ± 0.26
	b	–	–	–	–	–	–	–
Arginine[c]	a	5.30 ± 0.54	5.02 ± 0.54	4.75 ± 0.47	4.86 ± 0.44	5.05 ± 0.30	4.89 ± 0.41	4.55 ± 0.38
	b	4.06 ± 0.48	7.05 ± 0.46	3.30 ± 0.37	3.27 ± 0.34	2.35 ± 0.31	1.29 ± 0.29	1.84 ± 0.31
γ-aminobutyric acid	b	3.88 ± 0.33	2.41 ± 0.24	1.65 ± 0.23	1.63 ± 0.23	2.13 ± 0.20	1.63 ± 0.24	1.59 ± 0.30
Ornithine	b	1.37 ± 0.35	0.98 ± 0.22	0.81 ± 0.26	0.80 ± 0.24	1.58 ± 0.19	1.58 ± 0.21	1.18 ± 0.26
% Crude nitrogen		1.580 ± 0.32	1.507 ± 0.27	1.484 ± 0.31	1.476 ± 0.35	1.394 ± 0.35	1.376 ± 0.32	1.340 ± 0.33

[a] Determination for nonoxidized sample. Each value is the mean of eight determinations ± SD.
[b] (a) ion-exchange chromatography; (b) gas-liquid chromatography
[c] Essential amino acids

exchange chromatography data but strongly disagreed with those obtained by GLC. This is not surprizing since potatoes contain a rather reactive and unstable mix of compounds: free amino acids, proteins and carbohydrates among others. Both processing and analysis must have mild conditions if destruction is to be prevented.

As shown by ion-exchange chromatography, potato tuber processing into dehydrated granules by a freeze-thaw process caused only small losses in total amino acids and little change in their composition. There was only a 4.5% loss ($p < 0.05$) of total essential amino acids and a 2.1% loss ($p < 0.05$) in nonessential amino acids, excluding aspartic and glutamic acids, which comprised 48% peeled and sliced potatoes. In the granule process their content significantly decreased to 37.9% ($p < 0.05$), which was the only significant loss ($p < 0.05$) recorded by the granule process.

When the granule results are compared to potato flakes made by laboratory drum drying (Jaswal, 1973), the granule process appears much superior. In the granule process, essential amino acid destruction was less than half that for flakes, while the nonessential amino acid losses were similar and involved primarily significant losses ($p < 0.05$) of aspartic and glutamic acids. A previous study (Golan-Goldhirsh et al, 1982) revealed only the change of the free amino acid pool during processing. Peeled raw potato, after reaching the end product state, decreased ($p < 0.05$) its free amino acid pool by 40%.

The major loss of 27.3% ($p < 0.05$) occurred in the precooking step. Slightly more than half of the losses were assigned to essential amino acids. These data confirm the recent works of Talley et al. (1983, 1984) and Sullivan et al. (1985) where it was found that some losses of arginine, aspartic, glutamic and aminobutyric acids occurred during hot water blanching and a significant loss of methionine occurred during drum drying. However, amino acids can be considered quite stable during potato flake production. No other data are available in the existing literature on a granule process.

CONCLUSIONS

THE GRANULE PROCESS had little effect on the total amino acids and their composition. Only 4.5% destruction of essential amino acids and a total loss of 2.1% of nonessential acids classified the process as least detrimental for commercial potato processing.

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Ms received 2/17/87; revised 6/29/87; accepted 8/7/87.

The authors greatly acknowledge the Alberta potato dehydration industry for financial assistance (Alberta, Edmonton, Canada) and Prof. Trakhtenberg and Mr. A. Gorinstein (Israel) for their help with the statistical studies.

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Ms received 4/8/87; revised 7/10/87; accepted 8/3/87.