

## AMINO ACID COMPOSITION OF FRESHLY HARVESTED AND STORED POTATOES

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### Abstract

Total amino acid contents of several important U.S. potato cultivars grown in Maine, Idaho and The Red River Valley are listed along with nitrogen content. Differences in amino acid content among cultivars were roughly proportional to differences in total nitrogen. The effect of storage on amino acids in two cultivars was minor. The limiting essential amino acids compared to egg were MET and the sulphur amino acids.

### Resumen

Se presentan los contenidos de nitrógeno y del total de amino ácidos de varios cultivares de papa importantes para los Estados Unidos, y cultivados en Maine, Idaho y el Red River Valley. Las diferencias en el contenido de amino ácidos entre cultivares fue aproximadamente proporcional a las diferencias en el contenido de nitrógeno total. El efecto del almacenamiento sobre el contenido de amino ácidos en dos cultivares fue pequeño. Los amino ácidos esenciales más limitantes, comparados con los del huevo, fueron la metionina y los otros amino ácidos azufrados.

### Introduction

Potatoes rank number one by weight among all vegetable crops consumed by people in the United States (18). Thus, they play an important role in the daily American diet. Burton (3) pointed out that a disadvantage of potato as a staple foodstuff, compared with the cereals, is its low content of dry matter and associated low energy value. He noted, however, its great nutritional advantage is that intake of energy in the form of potatoes is accompanied by comparatively large intake of protein and other important dietary elements and that the biological value of potato protein, as shown by human feeding experiments, is very high. Thus, the potato is not a source of empty calories. Also, the potato has been ranked as the second most efficient crop

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in production of food calories per hectare (8), and second to soybeans in terms of protein (226 kg/ha for potatoes vs 470 kg/ha for soybeans) (9).

Knorr (8), in his review on the protein quality of potato and potato protein concentrates, reports that complete amino acid analyses of potato protein are rarely reported in the literature. Eppendorfer *et al.* (5) and Baerug *et al.* (2) have recently reported total amino acid analyses of European potatoes in connection with fertilization experiments. The National Potato Board has sponsored a study aimed at increasing the knowledge of the nutritive value of the potato. The total amino acid composition of several important U.S. potato varieties grown in three major production areas—Maine, Idaho, and The Red River Valley (MN and ND), is presented here as part of that study. The differences in raw and cooked potato peel and flesh are discussed in another paper (14). These samples have been analyzed for other nutrients besides amino acids (1, 16, 18).

### Materials and Methods

*Samples*—Sample collection, selection, and preparation have been described earlier by Toma *et al.* (16). The freeze-dried samples were received from the Red River Valley Potato Research Laboratory in small vials along with a list of nitrogen and moisture contents. Moisture ranged from about 0.3% to 9%. Samples were stored in the closed vials in a freezer at  $-10^{\circ}\text{C}$  after receipt. The cultivars included were Kennebec (KEN), Superior (SUP), Katahdin (KAT), Norchip (NOC), Russet Burbank (RUS), Centennial R X2 (Centennial Russet) (CEN), White Rose (WHR), Norgold Russet (NOG), and Red Pontiac (PON).

*Acid Hydrolysis*—Samples of approximately 0.05 g were weighed accurately into 250-ml round bottom flasks. One hundred milliliters of 6 N hydrochloric acid were added to each flask and the contents deaerated on a rotary evaporator before refluxing on a heating mantle under an air condenser for 24 hours. HCl was removed by rotary evaporation below  $40^{\circ}\text{C}$ . Extra water was added and re-evaporated to remove all but traces of HCl. The residue was quantitatively transferred with deionized water to a 5-ml volumetric flask, mixed after making to volume, and the humin allowed to settle out overnight under refrigeration. The supernatant, if not analyzed immediately, was transferred to a clean, dry vial and frozen ( $-10^{\circ}\text{C}$ ).

*Oxidation and Acid Hydrolysis*—The samples were weighed (0.05 g) into aluminum-capped test tubes and oxidized overnight with 2 ml of performic acid solution according to the procedure of Moore (10). After treatment with hydrobromic acid, the samples were transferred quantitatively to 250-ml round bottom flasks, the bromine and formic acid evaporated, and the acid hydrolysis carried out as described above.

*Tryptophan Determination*—The alkaline hydrolysis for tryptophan was done according to the procedure of Hugli and Moore (6), using samples

of about 0.1 g without added starch but with isopropanol as an antifoaming agent. The evacuated, sealed tubes were heated for 24 hours in an air oven at 110°C. The hydrolysates were transferred to 5-ml volumetric flasks containing the measured quantity of frozen, standardized hydrochloric acid, made to volume, and mixed. Any solid material present was allowed to settle out overnight under refrigeration, and the supernatants decanted with a dry syringe into dry vials (to prevent concentration changes) which were capped and stored in the freezer, if not determined immediately. Tryptophan in this mixture is lost on prolonged storage in the refrigerator but the loss is not noticeable for a month or two when the mixture is frozen (-10°C).

*Amino Acid Determination*—The amino acid contents of the hydrolysates were determined by a Beckman Automatic Amino Acid Analyzer, Model 119C, with a standard 0.9-cm column at 50°C with a buffer flow rate of 70 ml/hour and a ninhydrin flow rate of 35 ml/hour. The “A” buffer was pH 3.25 citrate, 0.20 M [Na<sup>+</sup>], and [citrate], which ran for 65.0 minutes; followed by pH 4.25 citrate, 0.20 M [Na<sup>+</sup>], and [citrate], for 50.0 minutes; followed by pH 7.32 citrate, 1.00 M [Na<sup>+</sup>], and 0.20 M [citrate]; the latter contained NaCl to increase the [Na<sup>+</sup>]. This latter buffer ran for 80.0 minutes, followed by 0.20 N NaOH for 5.0 minutes, followed by equilibration with “A” buffer for 30.0 minutes. One milliliter of pH 2.2, 0.20 M sodium citrate starting buffer was put into the sample holder, followed by a 100- $\mu$ l sample, and then 0.2 ml of “A” buffer. The results were calculated by Beckman’s System AA, a Spectrophysics microprocessor.

Tryptophan (TRP) determinations were carried out on a special 0.9-cm column with a resin depth of 5.5 cm, using Hugli and Moore’s (6) buffer, pH 5.4, 0.21 N Na<sup>+</sup>. This buffer ran for 40 minutes, NaOH for 5 minutes, equilibration for 20 minutes. The starting buffer in the sampler was pH 4.25 and the sample (100  $\mu$ l) was followed by pH 5.4 buffer.

The standard amino acid procedures for hydrolysates do not separate all the amino acids found in potatoes. The procedures used for this work separated cysteic acid (CYH), methionine sulfoxide (METSO), methionine sulfone (METSO<sub>2</sub>), glucosamine, *beta*-alanine (BAL), *gamma*-aminobutyric acid (GAM), and ornithine (ORN) from each other and from the 17 amino acids and ammonia in the usual standard mixtures for protein hydrolysates. Tryptophan would be separated also, if present, but since it is usually destroyed by acid hydrolysis, a separate procedure was used for it. The unoxidized acid hydrolysates were compared with the oxidized samples as checks, using the sums of the threonine (THR), glutamic acid (GLU), alanine (ALA), valine (VAL), isoleucine (ILE), leucine (LEU), GAM, Lysine (LYS), and arginine (ARG) values. These did not change appreciably on oxidation. The results obtained for the amino acids: CYH, METSO, METSO<sub>2</sub>, half cystine (CYS/2), methionine (MET), tyrosine (TYR), phenylalanine (PHE), histidine (HIS), and ornithine (ORN) were markedly different or inconsistent

in the oxidized and unoxidized samples. Experiments indicated that phenol had very little effect on the stability of tyrosine during hydrolysis. Tyrosine was usually completely destroyed in the oxidized sample. The methods were checked by spiking potato samples with 2x-crystallized *beta*-lactoglobulin A and with bovine serum albumin and checking recoveries. The settling out of humin overnight in the refrigerator, followed by decantation of the supernatant, produced results equivalent to millipore filtration and was easier.

Single determinations of the amino acids were made on each of the three replicates for the oxidized and the unoxidized materials and two determinations for tryptophan. (Where oxidation did not appreciably affect the amino acids, duplicate values were obtained on each replicate.) The original data are available but are not given in this report. Average values of the determinations are given for each treatment and a mean value for all the determinations represented in each table, as well as the lowest and highest values. Significant differences among treatments were evaluated by Duncan's (4) Multiple Range Test. Means in the same treatment followed by the same letter, were not significantly different at the  $p=0.05$  level. The coefficient of variation (CV) was calculated from the error term, which did not include the variation due to treatments (11) and thus is a measure of error due to the methods, replication, etc. and is *not* a measure of overall variation. This is in contrast to earlier papers of the series (1, 16, 18) where the variance values listed are for overall variation including treatments and the latter are much larger in magnitude.

## Results and Discussion

In general, all of the amino acids looked for in the samples were found with the following exceptions: 1) Methionine sulfone did not usually appear in the unoxidized potato samples. Traces of methionine sulfoxide, cystine, and methionine were often found in the oxidized samples; 2) glucosamine did not appear in these samples, but a peak in the glucosamine position has been found in other samples of potatoes; and 3) *beta*-alanine, found in free amino acid samples in earlier studies (12) when a more sensitive procedure was used, may have occurred in traces but was not detected in this study. It would be expected to be among the total amino acids. *Beta*-alanine probably is not destroyed to a large extent by acid hydrolysis, but would be expected to be present in only very small amounts. The color yield of *beta*-alanine compared to leucine also was only about one third of that found in the former work.

Table 1 lists the mean values for five cultivars from Maine at harvest, in descending order of nitrogen content. In general, the concentrations of the individual amino acids followed the same order as the nitrogen content. However, in many cases where the order was not followed, the values were not significantly different. Table 2 lists the mean values for 6 lots of Idaho

TABLE 1. — Nitrogen and total amino acid contents of five potato cultivars grown in Maine (at harvest).

VAR <sup>1</sup>	KEN <sup>2</sup>	SUP	KAT	NOC	RUS	Low <sup>3</sup>	High	CV	Mean
Micromoles amino acid per gram potato (dry basis)									
No.	3	3	3	3	3	15	15	15	15
Nitrogen	1344a	1276ab	1222b	1124c	1123c	1112	1396	3.0	1218
CYH (ox)	12.0a	11.1ab	10.3b	10.9ab	9.7b	9.1	12.2	6.6	10.8
ASP	180.0a	184.8a	174.2a	142.9b	152.8b	136.6	191.4	5.1	166.9
METSO <sub>2</sub> (ox)	12.4a	10.8ab	11.2ab	10.4b	10.4b	9.0	12.7	7.8	11.0
THR	27.4b	30.8a	23.2c	26.0cb	20.0d	18.3	31.0	6.8	25.5
SER	34.1a	34.1a	30.5b	31.7ab	25.0c	24.3	36.0	5.2	31.1
GLU	154.7a	122.5b	104.9c	106.6c	105.2c	98.7	156.5	5.1	118.8
PRO	24.3b	34.8a	22.1cb	25.4b	18.2c	15.4	35.9	10.6	24.9
GLY	37.5ab	40.1a	33.0c	34.5cb	26.7d	24.4	42.5	6.9	33.4
ALA	32.5a	33.2a	28.6b	30.4ab	23.6c	22.0	34.4	5.2	30.0
VAL	47.8a	44.8a	38.7b	37.8b	35.3b	33.5	49.9	6.0	40.9
ILE	28.8a	27.5a	23.4cb	24.3b	20.9c	20.0	30.7	6.0	25.0
LEU	40.8a	42.9a	34.2b	36.1b	28.3c	26.1	45.4	6.6	36.5
TYR	21.0a	18.8b	16.1c	16.0c	14.8c	14.5	21.8	4.7	17.3
PHE	24.9a	24.4a	20.1b	20.6b	17.6c	16.9	25.9	5.4	21.5
GAM	19.1b	22.9a	23.9a	20.8ab	24.0a	17.0	26.3	8.8	22.1
HIS	13.9a	11.7b	11.1b	9.9c	9.7c	9.5	14.8	5.8	11.3
ORN	1.3a	0.6ab	0.3b	1.2a	0.2b	0.0	1.5	51.2	0.8
LYS	34.6a	33.4a	28.3cb	31.5ab	25.6c	23.9	36.5	7.4	30.7
NH <sub>3</sub>	118.3a	120.1a	133.1a	116.0a	114.0a	89.4	147.7	15.4	120.3
ARG	37.7a	34.2b	25.4c	32.8b	23.6c	22.5	39.3	6.3	30.7
TRP	5.6a	4.3b	4.4b	4.0b	4.1b	3.8	6.2	7.2	4.5

<sup>1</sup>VARIABLE; No. = number of determinations in the group (treatment) average; Nitrogen (Kjeldahl); CYH = cysteic acid, a measure of original cystine and cysteine, determined on the oxidized sample; METSO<sub>2</sub> = methionine sulfone, a measure of original methionine, determined on the oxidized sample; GAM = *gamma*-aminobutyric acid and the remaining symbols of amino acids have their usual identification. TRP values are calculated using twice the number of determinations as was used for the other amino acids.

<sup>2</sup>Averages for the cultivar named of the number of items listed under No.; KEN = KENnebec; SUPerior; KATahdin; NOChip; RUSset Burbank. Averages followed by the same letter are not significantly different at the p = 0.05 level.

<sup>3</sup>See the text for the significance of these terms.

TABLE 2. — Nitrogen and total amino acid contents of six potato cultivars grown in Idaho (at harvest).

VAR <sup>1</sup>	CEN <sup>2</sup>	KEN	WHR	KTW	NOG	RUS	Low <sup>3</sup>	High	CV	Mean
Micromoles amino acid per gram (dry basis)										
No.	3	3	3	3	3	3	18	18	18	18
Nitrogen	1456a	1290b	982c	986c	975c	926c	868	1513	5.3	1103
CYH (ox)	14.4a	10.5b	10.2b	10.4b	10.3b	8.8b	8.4	15.4	9.6	10.8
ASP	205.0a	171.8b	134.6c	126.1d	123.9d	147.5c	116.7	205.3	5.8	151.5
METSO <sub>2</sub> (ox)	13.1a	13.2a	11.3b	12.0ab	12.1ab	9.6c	9.4	13.4	5.3	11.9
THR	34.2a	28.3b	24.1cd	24.9c	23.7cd	21.4d	20.4	35.9	6.6	26.1
SER	47.0a	40.9b	29.0c	29.3c	29.8c	25.8c	23.8	48.6	8.0	33.6
GLU	134.6b	151.0a	99.3d	117.2c	126.0cb	87.7d	81.7	164.1	7.0	119.3
PRO	60.8a	28.0b	19.2cd	24.0cb	21.8c	16.5d	15.6	63.6	9.8	28.4
GLY	49.5a	39.9b	30.8d	34.6c	32.3cd	29.3d	28.2	52.0	5.3	36.1
ALA	51.4a	42.7b	32.2c	32.2c	31.3c	24.3d	22.3	53.4	5.5	35.7
VAL	58.9a	49.1b	40.3c	41.1c	42.2c	38.4c	36.3	61.9	6.6	45.0
ILE	35.4a	29.2b	23.5cd	25.0c	22.1d	22.7cd	21.4	36.3	5.4	26.3
LEU	50.1a	43.6b	31.1d	38.1c	33.7d	31.8d	30.3	52.7	6.1	38.1
TYR	24.1a	21.6b	17.5c	16.0cd	14.7d	18.0c	14.2	26.0	6.4	18.6
PHE	31.4a	26.1b	20.2cd	22.0c	17.6e	19.2ed	16.7	32.9	5.2	22.8
GAM	21.6a	17.1b	15.5b	14.8cb	16.8b	12.9c	12.8	21.9	8.0	16.4
HIS	14.7a	11.1b	8.8d	10.6cb	8.9d	9.7cd	8.0	15.1	5.3	10.6
ORN	1.5a	1.0ab	0.5cb	1.0ab	0.3c	0.4c	0.0	1.7	39.2	0.8
LYS	45.2a	36.5b	28.0c	31.0c	28.3c	26.6c	23.5	46.8	7.4	32.6
NH <sub>3</sub>	100.4a	128.9a	128.0a	116.5a	105.9a	98.8a	76.4	218.6	34.6	113.1
ARG	37.2a	33.2a	24.0b	26.0b	22.1b	23.6b	20.1	39.7	9.5	27.7
TRP	4.9b	5.8a	4.6b	3.7c	3.5c	4.4b	3.0	6.9	11.8	4.4

<sup>1</sup>See under Table 1.

<sup>2</sup>Averages of the number of items listed under No.; CENtennial R X2 (Centennial Russet); KENnebec; WHite Rose; KTW = Kennebec (a second sample combined from two locations); NOGold (Norgold Russet)(sample combined from two locations); RUSset Burbank (single sample combined from three locations); means followed by the same letter are not significantly different at the p=0.05 level.

<sup>3</sup>See text.

potatoes. As indicated in earlier studies (12), the higher solids potatoes generally found in Idaho, have a lower nitrogen and amino acid content than the lower solids ones from Maine. In this Table, CEN and KEN are exceptions. Table 3 includes 4 lots of Red River Valley potatoes. Here, SUP shows a typical low solids result but KEN, of essentially the same moisture content as SUP, is much lower in nitrogen and amino acids. In a single cultivar, KEN, grown in all three locations (Table 4), the nitrogen and amino values are lower for the Red River Valley except that proline (PRO) and ammonia (NH<sub>3</sub>) are not significantly different from that found in KEN at the other two locations. Whether these differences may be due to location or to other factors is not known.

Katahdin and Russet Burbank, both grown in Maine, had been held at two storage temperatures at 95% relative humidity for 4 months (Table 5) (16). The results show that the Katahdin cultivar was higher in nitrogen and in most of the amino acids. CYH (cystine-cysteine), GLU, TYR, GAM, NH<sub>3</sub>, and ARG were not significantly different for the two cultivars. ORN and TRP were significantly higher in the Russet Burbank. Higher nitrogen values occurred at lower storage temperature, 3.3°C, and were higher in both stored treatments than at harvest, although at 7.2°C, the difference was not significant. There was little change in the dry matter content of the potatoes during storage (16), thus, the differences cannot be explained on that basis. But since potatoes are living organisms, both moisture and dry matter may have been lost during storage. We do not know whether the potatoes had the same weight when they went into storage as they did when they came out. The differences were not significant for MET (measured as METSO<sub>2</sub>), ILE, TYR, and ORN. CYH, aspartic acid (ASP), GLU, LYS, NH<sub>3</sub>, ARG, and TRP increased on storage at 7.2°C, and ALA showed the opposite trend. ASP, THR, serine (SER), PRO, glycine (GLY), VAL, LEU, PHE, HIS, LYS, ARG, and TRP increased on storage at 3.3°C, and GLU and NH<sub>3</sub> decreased. (Extraneous ammonia is very easily absorbed by acid reagents such as buffers, HCl, etc., and, as indicated by the high coefficient of variation, is not very accurately determined.) In addition to the above comparisons, some apparent interactions took place not brought out in the comparison of the overall means. Proline increased significantly on storage in Katahdin but the change was insignificant at 3.3°C and significantly decreased at 7.2°C in Russet Burbank. Russet Burbank showed significant decreases in ILE and LEU at 7.2°C, but not much change occurred at 3.3°C. The changes in ILE and LEU in Katahdin were not significant. Katahdin showed decreases in ORN on storage but Russet Burbank showed increases.

The maximum and minimum mean values from Tables 1-5, of the essential amino acids and of nitrogen are listed in Table 6 to show the maximum range found. These are compared with equivalent values for hen's eggs, calculated from the FAO/WHO Report No. 301 (19). Only about half

TABLE 3. — Nitrogen and total amino acids at harvest of four potato cultivars grown in the Red River Valley.

VAR <sup>1</sup>	SUP <sup>2</sup>	PON	NOC	KEN	Low <sup>3</sup>	High	CV	Mean
Micromoles amino acid per gram potato (dry basis)								
Mois <sup>4</sup> %	79.4	77.4	74.6	79.0				
No.	3	3	3	3	12	12	12	12
Nitrogen	1336a	954b	941b	898b	875	1393	4.7	1032
CYH (ox)	12.2a	9.4b	8.3b	9.3b	8.0	12.3	13.1	9.8
ASP	195.4a	116.4b	111.7b	107.0b	101.8	204.0	4.8	132.6
METSO <sub>2</sub> (ox)	12.2a	10.5ab	9.2b	10.1ab	8.2	13.0	10.3	10.5
THR	25.4a	22.8a	22.5a	22.5a	19.5	26.5	6.9	23.3
SER	27.6a	27.9a	27.9a	28.6a	26.2	29.6	4.5	28.0
GLU	123.6a	115.9ab	89.9c	106.5b	87.1	125.1	5.4	109.1
PRO	21.9ab	19.6b	25.0a	21.8ab	19.0	27.1	11.1	22.1
GLY	35.4a	33.2ab	32.1b	33.4ab	31.0	36.4	3.6	33.5
ALA	29.8ab	30.2a	27.0b	28.1ab	26.7	31.0	3.9	28.5
VAL	39.7ab	41.6a	33.4c	36.3cb	32.1	42.8	5.8	37.7
ILE	25.1a	23.1b	21.3b	22.0b	20.3	26.1	4.3	22.9
LEU	36.3a	35.1ab	34.0b	37.3a	31.7	38.8	4.3	35.7
TYR	20.2a	13.2b	13.2b	13.1b	12.6	20.9	4.8	14.9
PHE	23.0a	17.6b	18.4b	17.6b	16.9	24.3	5.0	19.2
GAM	19.8a	18.8a	19.9a	13.6b	12.3	22.8	9.1	18.1
HIS	11.3a	8.0ab	8.1ab	6.5b	4.3	11.8	20.5	8.5
ORN	0.1ab	0.5a	0.5a	0.0b	0.0	0.8	90.2	0.3
LYS	31.9a	30.0a	27.8a	29.1a	24.7	36.2	8.3	29.7
NH <sub>3</sub>	166.1a	142.4ab	119.6b	136.9ab	93.5	176.4	15.2	141.2
ARG	31.5a	23.5b	26.0b	24.5b	22.2	35.0	7.3	26.4
TRP	4.4a	3.2cb	3.1c	3.3b	2.8	4.5	5.2	3.5

<sup>1</sup>See under Table 1.

<sup>2</sup>See under Tables 1 and 2; SUPERior; PONtiac; NORchip; KENnebec; means followed by the same letter are not significantly different at the p = 0.05 level.

<sup>3</sup>See text.

<sup>4</sup>MOISture, %, of fresh potatoes.

TABLE 4. — Nitrogen and total amino acid content at harvest Kennebec potatoes grown in three different locations.

VAR <sup>1</sup>	MAI <sup>2</sup>	IDA	RRV	Low <sup>3</sup>	High	CV	Mean
	Micromoles amino acid per gram potato (dry basis)						
No.	3	3	3	9	9	9	9
Nitrogen	1344a	1290a	898b	879	1396	4.9	1177
CYH (ox)	12.0a	10.5ab	9.3b	8.1	12.2	9.5	10.6
ASP	180.0a	171.8a	107.0b	101.8	185.0	7.1	152.9
METSO <sub>2</sub> (ox)	12.4a	13.2a	10.1b	9.2	13.4	5.8	11.9
THR	27.4a	28.3a	25.5b	21.7	31.2	7.6	26.1
SER	34.1b	40.9a	28.6b	27.6	45.2	8.1	34.5
GLU	154.7a	150.3a	106.5b	99.4	164.1	7.6	137.4
PRO	24.3a	28.0a	21.8a	19.0	33.7	17.0	24.7
GLY	37.5ab	39.9a	33.4b	32.7	43.3	6.1	37.0
ALA	32.5b	42.7a	28.1c	27.5	45.8	5.4	34.4
VAL	47.8a	49.1a	36.3b	34.6	52.9	7.1	44.4
ILE	28.8a	29.2a	22.0b	21.4	30.9	6.4	26.7
LEU	40.8ab	43.6a	37.3b	36.2	46.6	5.9	40.6
TYR	21.0a	21.6a	13.1b	12.8	23.7	6.1	18.8
PHE	24.9a	26.1a	17.6b	17.0	27.7	5.2	22.9
GAM	19.1a	17.1ab	13.6b	12.3	20.6	12.7	16.6
HIS	13.9a	11.1b	6.5c	4.3	14.8	12.0	10.5
ORN	1.3a	1.0a	0.0b	0.0	1.5	23.9	0.8
LYS	34.6a	36.5a	29.1b	28.6	38.5	5.4	33.4
NH <sub>3</sub>	118.3a	128.9a	136.9a	89.4	151.6	20.7	128.0
ARG	37.7a	33.2a	24.5b	24.0	39.3	7.5	31.8
TRP	5.6a	5.8a	3.3b	3.1	6.9	13.9	4.9

<sup>1</sup>See under Table 1.

<sup>2</sup>See under Tables 1 and 2; MAIne; IDAho; RRV = Red River Valley.

<sup>3</sup>See text.

TABLE 5. — Comparison of total nitrogen and amino acids in Katahdin and Russet Burbank potatoes at harvest and after 4 months at two temperatures.

VAR <sup>1</sup>	KAT <sup>2</sup> (har)	KAT (3.3°C)	KAT (7.2°C)	RUS (har)	RUS (3.3°C)	RUS (7.2°C)	Har <sup>3</sup>	3.3°C	7.2°C	KAT <sup>4</sup>	RUS	Low <sup>5</sup>	High	CV	Mean
Micromoles per gram potato (dry basis)															
Nitrogen	1222	1321	1248	1124	1237	1163	1173Ab	1279a	1205A	1264a	1174b	1107	1378	4.3	1219
No.	6	12	12	6	12	12	12	24	24	30	30	60	60	60	60
CYH (ox)	10.3	10.9	12.0	9.7	10.7	10.7	10.0Ba	10.8a	11.3A	11.1a	10.4a	9.1	15.2	8.8	10.9
ASP	174.0	197.3	189.8	157.6	191.4	179.5	165.8Bb	194.3a	184.6A	193.5a	185.4b	152.5	221.8	5.6	184.7
METSO <sub>2</sub> (ox)	11.2	11.3	10.9	10.4	9.4	9.3	10.8Aa	10.3a	10.1A	11.1a	9.7b	7.6	12.1	7.9	10.3
THR	23.8	26.2	24.9	20.1	20.0	19.5	21.9Ab	23.1a	22.2A	24.9a	20.2b	17.3	29.6	7.1	22.7
SER	29.0	31.2	30.0	24.7	28.3	26.4	26.8Ab	29.8a	28.2A	30.1a	26.5b	24.5	37.9	7.0	28.6
GLU	107.8	112.9	98.1	107.0	109.2	102.8	107.4Ab	111.1a	100.5B	106.3a	106.3a	79.2	123.2	6.4	106.1
PRO	23.6	28.9	25.8	19.4	19.1	16.7	21.5Ab	24.0a	21.3A	26.1a	18.4b	15.4	32.8	11.9	22.4
GLY	34.6	37.8	36.3	27.5	29.7	27.1	31.1Ab	33.7a	31.7A	36.2a	28.1b	24.4	41.5	7.1	32.3
ALA	29.7	30.7	28.5	24.1	23.6	21.8	26.9Aa	27.2a	25.1B	29.6a	23.1b	19.6	33.1	6.2	26.3
VAL	38.8	41.3	39.8	36.1	38.2	35.3	37.4Ab	39.7a	37.6A	40.0a	36.5b	33.5	44.2	5.7	38.4
ILE	24.0	25.5	24.8	21.7	22.2	20.0	22.9Aa	23.8a	22.4A	24.8a	21.3b	18.2	28.0	5.8	23.1
LEU	35.1	38.7	36.4	29.3	29.5	26.4	32.2Ab	34.1a	31.4A	36.8a	28.4b	26.2	42.2	7.1	32.7
TYR	16.1	15.3	14.7	14.8	16.0	14.7	15.4Ab	15.7a	14.7A	15.4a	15.2a	13.2	17.7	7.8	15.2
PHE	20.1	21.8	20.5	17.6	18.9	18.3	18.9Ab	20.4a	19.4A	20.8a	18.3b	16.9	23.1	5.8	19.7
GAM	23.7	24.1	24.5	24.2	25.6	23.3	24.0Aa	24.9a	23.9A	24.1a	24.4a	21.1	34.6	8.1	24.3
HIS	11.0	12.4	10.7	9.7	11.8	10.6	10.4Ab	12.1a	10.6A	11.4a	10.7b	9.6	13.2	5.3	11.2
ORN	1.0	0.8	0.9	0.6	1.4	1.2	0.8Aa	1.1a	1.1A	0.9b	1.2a	0.6	1.7	17.9	1.1
LYS	28.2	33.9	31.9	24.0	29.2	26.9	26.1Bb	31.6a	29.4A	31.3a	26.7b	21.1	37.1	8.4	29.7
NH <sub>2</sub>	145.9	135.5	150.1	114.9	151.3	210.1	130.4Ba	143.4b	180.1A	143.8a	158.8a	55.3	254.5	24.2	155.5
ARG	25.8	31.4	28.9	24.0	29.0	29.6	24.9Bb	30.2a	29.3A	28.7a	27.5a	22.9	41.6	12.3	28.8
No.	6	6	6	6	6	6	12	12	12	18	18	36	36	36	36
TRP	4.4	4.9	4.0	4.1	5.6	5.5	4.2Bb	5.2a	4.8A	4.4b	4.8a	3.3	6.2	11.9	4.7

<sup>1</sup>See under Table 1, CYH, METSO<sub>2</sub>, TYR, PHE, HIS, and ORN have half the number of items averaged as for the remainder.

<sup>2</sup>Mean values; KAT = Katahdin cultivar at harvest and after storage at 3.3°C and 7.2°C; RUS = Russet Burbank at harvest and after storage at 3.3°C and at 7.2°C.

<sup>3</sup>Averages for all samples of both cultivars at harvest and after storage at 3.3°C and at 7.2°C, to show effects of storage; means followed by the same letter are not significantly different from harvest, caps at 7.2°C and small letters at 3.3°C at the p=0.05 level.

<sup>4</sup>Mean values for all values of KAT and RUS, respectively; means followed by the same letter are not significantly different from the other cultivar at the p=0.05 level.

<sup>5</sup>See text.

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TABLE 6. — Comparison of the potato essential amino acids and nitrogen with those of egg (dry weight basis).

Component	potato		egg <sup>2</sup>	potato equivalent	
	Max <sup>1</sup>	Min <sup>1</sup>		Max <sup>3</sup>	Min <sup>3</sup>
Nitrogen	%			g/g	
	2.04	1.26	16.0		
	μmole/g				
Nitrogen	1456	898	11420	7.8	12.7
CYH	14.4	8.3	200	13.8	23.9
MET	13.2	9.2	208	15.7	22.6
Total S	27.6	17.5	408	14.8	23.3
ILE	35.4	20.2	503	14.2	24.9
LEU	50.1	27.1	671	13.4	24.8
LYS	45.2	25.6	438	9.7	17.1
PHE	31.4	17.6	351	11.2	19.9
TYR	24.1	13.1	232	9.6	17.7
Total aromatics	55.5	30.7	583	10.5	19.0
THR	34.2	20.0	428	12.5	21.4
TRP	5.8	3.1	78	13.4	25.2
VAL	58.9	33.4	623	10.6	18.7
Total essential amino acids	312.7	177.6	3732	11.9	21.0

<sup>1</sup>Max, Min = Maximum and minimum mean values from Tables 1 to 5, μmoles/g, see text for explanation.

<sup>2</sup>Egg-μmole/g DWB from FAO/WHO Report No. 301 (19).

<sup>3</sup>Max, Min = grams of Max and Min potato equivalent to 1 g of egg.

or less of the nitrogen in potatoes is in the form of true protein, the remainder is in much smaller molecules, such as amides and free amino acids and even compounds unrelated to proteins. Eppendorfer, *et al.* (5) reported that under normal growing conditions, about 50% of the total-N is true protein, the amide and free amino acid fraction accounts for approximately 40%, leaving about 10% of the total nitrogen unrelated to proteins. The work of Talley, *et al.* (12) indicates similar results. Markakis (9) has listed basic N as 8% of the total nitrogen and has suggested that this may include alkaloids, certain vitamins, purines, pyrimidines, quarternary ammonium compounds, etc. Talley (13) has shown that comparisons based on nitrogen content alone may be misleading. In the light of these facts, the comparisons in Table 6 are made on the dry weight basis and not on the nitrogen basis. The minimum and maximum number of grams of potato equivalent to 1 g of egg are listed to indicate the limiting essential amino acids compared with egg. The highest value for the potato equivalent weight (lowest content)

probably is for MET, which indicates that it may be the limiting essential amino acid compared to egg. On this basis, the sulfur-bearing amino acids, as a group, come next, with ILE third. Potatoes are highest in LYS in contrast to cereals where it is usually limiting; LYS and TYR show the lowest values of equivalent weights (highest contents). The nitrogen potato equivalent weight is low compared to the amino acids, probably because of the presence of nitrogen containing compounds in the potato not related to proteins, as pointed out above. (Cf. also 7, 17, 15, 13.)

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