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AMINO ACID CONTENT OF BEEF, CHICKEN AND TURKEY BONE BROTH

M.H. Shaw* and N.E. Flynn†

Department of Chemistry and Physics, West Texas A&M University, Canyon, TX 79016

Abstract

Bone broths have recently become a trend beverage that has acquired a reputation as the next magic potion for health. Despite public interest in bone broth most, if not all, of the health claims made regarding it have not been scientifically evaluated and this includes amino acid content. Nineteen individual amino acids in bone broth from beef, chicken and turkey were quantified. Arginine, glutamate, hydroxylysine, hydroxyproline and proline were of interest and could potentially explain reported health benefits from bone broth which include protecting joints and boosting the immune system. Commercial samples were analyzed using ninhydrin post column HPLC derivatization and norleucine as internal standard. Results were compared to published plasma and animal protein values. Bone broths do not appear to be a better source of amino acids.

†Corresponding author: nflynn@wtamu.edu

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Introduction

This work reports amino acid content of commercial samples of beef, chicken and turkey bone broth. Bone broths have recently become a trend beverage that has acquired a reputation as an elixir for all that ails you[1]. This research allowed for significant insight into claimed health benefits of bone broth. In order to evaluate these claims, published concentrations of amino acids within various sources from the same species were analyzed[2-7].

Specific amino acids of interest included arginine, glutamate (expressed as glutamine), hydroxylysine, hydroxyproline and proline since increased values of these in bone broths would support health claims. A maintained level of increased nitric oxide production, produced from arginine, is known to improve cardiovascular health, ensure muscle growth, and strengthen the immune system. These attributes help to prevent arteriosclerosis and prevent heart attacks by moderating the level of homocysteine in the blood[8, 9]. Glutamine is a non-essential amino acid derived from glutamate and is known for increasing water retention within cells, helping to signal growth, and intensify production of protein and glycogen[10, 11]. Glutamine also enhances cell regeneration, glutathione production, and gut health[12, 13]. Hydroxylysine and hydroxyproline and glycine are key components in collagen and are known to interact with other collagen amino acids to form the collagen tripeptide molecule. Proline is beneficial for skin health through increased collagen production thus making it crucial for wound healing[14]. If one or more of these amino acids were to be elevated in bone broth or bone broth from one particular species this could help support manufacturer claims.

Experimental Methods

Sample Selection

A total of 15 samples for bone broth analysis were obtained from a health food store and were selected based upon expiration date and lot number. These samples were cataloged in a laboratory at West Texas A&M University and shipped intact to AAA Service Laboratory for analysis.

Equipment and Methods

The equipment used for analysis consisted of that used by the Amino Acid Analysis Service Laboratory (AAA Service Laboratory) based on a post-column, ninhydrin derivatization method published by Macchi *et al*[15] except a Hitachi L8900 Amino Acid Analyzer was used. The methods and analyzer used allow for proteins of higher salt concentrations to be analyzed[16, 17]. Exactly 50 µL of sample was used for analysis. Amino acid values were expressed on a per gram product basis. For this method, the limit of detection is 150 pmoles amino acid while the limit of quantitation is 450pmoles.

Analysis

Analysis of the results focused on the mg amino acid per gram product in order to compare each amino acid value for each individual sample. A one-way analysis of variance (ANOVA) was used to test for differences across the 15 samples for each analyzed amino acid. Tukey's post hoc analysis was used to determine the difference in means for each amino acid between the three types of bone broth. Amino acid values were expressed as mean ± S.E.M.

Results and Discussion

Comparison against known values

Average protein content of bone broths was 23.2 ± 0.71 mg/gram product. Table 1 provides the mean ± S.E.M. of each analyzed bone broth amino acid. For all but five of the amino acids analyzed, turkey bone broth exhibited the highest individual amino acid concentration compared to beef or chicken bone broth. Arginine and glutamate were highest in turkey bone broth while hydroxylysine was highest in beef bone broth and hydroxyproline as well proline were highest in chicken bone broth. Next to glycine in beef and chicken broth, glutamate exhibited the highest concentration among the analyzed amino acids with turkey broth demonstrating the highest value. Given the small number of publications regarding amino acid content of bone broth and that most articles offer only qualitative discussions surrounding the topic[1, 18] it became necessary to compare bone broth amino acid concentrations to alternate sources from the same animals. Given that these data originate from different sources and different methodologies we will focus our discussion on the relative concentration of amino acids within each referenced source.

While glutamate was the first or second highest amino acid in

bone broths, it is apparent that glutamate concentrations are also highest among published amino acid concentrations from other sources from the same animals[3, 5, 17] (Table 2). As stated by other articles, this very prominent value of glutamate is derived from its large abundance in collagen. It is also likely that skeletal muscle remaining on bones used for bone broth preparation lead to the high glutamate levels as glutamate and glutamine are well known for their high concentration in skeletal muscle. Other prominent amino acids that compose collagen are alanine, arginine, aspartic acid, leucine, lysine, serine, glycine, and proline with glycine and proline being the largest component of collagen[5]. Due to this fact, we expected these amino acids to also have elevated levels in comparison to other amino acids found in bone broth given its source. Proline is second highest in concentration among the selected amino acids with chicken broth having the highest concentration at 2.440 ± 0.078 mg/g (Table 1). As mentioned, proline is a major component in collagen. Comparing the concentration of proline against published data, it is evident that proline exhibits a similar relative concentration level among two of the three reported sources. Proline concentration for pork in De La Haba *et al*[2] is the closest example of elevated concentration levels in relation to bone broth. As evident in this study, the higher concentration of

Table 1. mg amino acid / gram product

Amino Acids	Beef Broth	Chicken Broth	Turkey Broth
Arginine (R)	1.472 ± 0.025; a	1.892 ± 0.021; b*	1.976 ± 0.011; c*
Glutamine (E)	2.576 ± 0.040; a	3.473 ± 0.074; b	4.185 ± 0.079; c
Hydroxylysine	0.285 ± 0.006; b	0.276 ± 0.003; b	0.198 ± 0.003; a
Hydroxyproline	1.967 ± 0.314; b	2.158 ± 0.017; c	1.609 ± 0.015; a
Proline (P)	2.211 ± 0.034; b	2.440 ± 0.078; c	1.758 ± 0.012; a
Alanine (A)	1.617 ± 0.025; a	1.969 ± 0.016; b	1.938 ± 0.017; b
Aspartate (D)	1.227 ± 0.016; a	1.714 ± 0.038; b	2.064 ± 0.017; c
Glycine (G)	3.709 ± 0.059; b	4.063 ± 0.027; c	3.313 ± 0.018; a
Histidine (H)	0.260 ± 0.005; a	0.423 ± 0.012; b	0.535 ± 0.004; c
Isoleucine (I)	0.326 ± 0.005; a	0.492 ± 0.020; b	0.697 ± 0.005; c
Leucine (L)	0.726 ± 0.011; a	1.053 ± 0.036; b	1.426 ± 0.011; c
Lysine (K)	0.570 ± 0.008; a	0.964 ± 0.036; b	1.477 ± 0.013; c
Methionine (M)	0.211 ± 0.004; a	0.375 ± 0.012; b	0.509 ± 0.003; c
Phenylalanine (F)	0.586 ± 0.019; a	0.589 ± 0.020; a	0.611 ± 0.005; a
Serine (S)	0.662 ± 0.010; a	0.775 ± 0.019; b	0.916 ± 0.008; c
Threonine (T)	0.438 ± 0.006; a	0.681 ± 0.021; b	0.854 ± 0.006; c
Tyrosine (Y)	0.444 ± 0.010; a	0.529 ± 0.012; b	0.574 ± 0.011; c
Valine (V)	0.487 ± 0.008; a	0.645 ± 0.022; b	0.824 ± 0.006; c

* $p < 0.05$
All other $p < 0.01$

Values are expressed as mg amino acid per gram of bone broth on the basis of mean ± S.E.M. Amino acids of initial interest for this study are presented first while others are listed in alphabetical order. Values for amino acids with different letters are different as analyzed by One Way ANOVA followed by Tukey's post hoc analysis. Exactly 50 µL of sample was used for analysis; average protein content of bone broths was 23.2 ± 0.71 mg/gram product.

Table 2. Amino acid content of various animal products

Amino Acids	Turkey*	Chicken		Poultry			Cattle	
Reference	a[3]	a[3]	b[2,†]	c[4]	a[3]	b[2]	c[4]	d[7,‡]
Arginine (R)	6.5	6.7	4.22	4.22	6.4	3.09	3.59	1.65
Glutamine (E)	n/a	n/a	7.77	n/a	n/a	5.88	n/a	3.55
Hydroxylysine	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hydroxyproline	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.42
Proline (P)	n/a	n/a	4.42	n/a	n/a	4.13	n/a	1.23
Alanine (A)	n/a	n/a	4.25	n/a	n/a	3.55	n/a	1.57
Aspartate (D)	n/a	n/a	4.81	n/a	n/a	3.86	n/a	2.17
Glycine (G)	n/a	n/a	7.00	n/a	n/a	5.43	n/a	1.60
Histidine (H)	3.0	2.0	1.22	n/a	3.3	0.94	n/a	0.70
Isoleucine (I)	5.0	4.1	2.10	2.24	5.2	1.67	1.52	1.01
Leucine (L)	7.6	6.6	3.86	4.14	7.8	3.42	3.38	1.94
Lysine (K)	9.0	7.5	3.66	3.46	8.6	2.6	2.72	2.44
Methionine (M)	2.6	1.8	1.16	1.12	2.7	0.73	0.71	0.40
Phenylalanine (F)	3.7	4.0	2.21	n/a	3.9	1.9	n/a	0.92
Serine (S)	n/a	n/a	2.35	n/a	n/a	2.46	n/a	0.99
Threonine (T)	4.0	4.0	2.18	2.29	4.5	1.88	1.77	1.05
Tyrosine (Y)	1.5	2.5	1.66	n/a	3.0	1.31	n/a	0.75
Valine (V)	5.1	6.7	2.60	2.86	5.1	2.55	2.41	1.06

*Average concentration for whole turkey (breast and leg)
†Average concentration for poultry product; includes other poultry species
‡Average concentration for cooked cattle beef across three age groups
a) Essary (1968) (Expressed as gram amino acid/100 gram protein)[3]
b) De La Haba (2006) (Expressed as %)[2]
c) Fontaine (2001) (Expressed as amino acid content relative to crude protein)[4]
d) Schönfeldt (2010) (Expressed on a wet mass basis)[7]

proline is directly related to the use of bones to produce the broth. The concentration of hydroxyproline should also be elevated where proline is, due to its known requirement in formation of tripeptide collagen molecules involving proline; however, this cannot be determined from available data for other anatomical sources due to the fact that hydroxyproline is not commonly analyzed when amino acids are studied. For similar reasons, we cannot draw any conclusions regarding hydroxylysine.

Arginine has the highest concentration in turkey broth at 1.976 ± 0.011 mg amino acid / gram product (Table 1). In published turkey products, concentrations of arginine are also relatively high[3]. Examining Table 1 further, glycine is also in high abundance in all three bone broth samples. It is commonly known that glycine concentrations are high in most protein sources. Glycine is responsible in many ways for enhancing protein absorption and is also produced in other amino acids metabolic reactions, such as threonine and serine[19]. It is worth noting that glycine is also important to collage protein structure.

Examining amino acid concentrations in PAP from De La Haba *et al*[2] (Table 2), values of poultry, pork, meat and bone meal, and cattle meal are presented. The article only represents a category for poultry as opposed to turkey or chicken. It is possible, however, to compare both the chicken and turkey concentrations provided by our research against whole poultry concentrations. It is also possible to compare cattle meal concentration to beef broth concentration in this study. Glutamate has the highest average across the four different samples. The concentrations from De La Haba *et al*[2] for glutamate is relatively higher on a comparative basis to other amino acids than in our study.

Finally, it does need to be noted that samples for this study were collected from commercially available sources and not produced in the lab. The primary reason for doing this was to obtain real word data on both broth amino acid content in commercial samples. Variables such as time and temperature were intentionally not controlled in an effort to provide representative data regarding these commercial products.

Conclusions

This study is important because it provides a better understanding of the potential contribution of bone broth to general health and will aid nutritionists in making recommendations to their clients. A comparison of the broth concentrations to meat and PAP concentrations allows us to see that while bone broths may have an ability to contribute vital amino acids on a dietary basis, they do not appear to be a significantly better source when compared to other animal protein products. Our results, therefore, do not support claims made by nutritional supplement companies. Given this and the fact that bones are known to sequester one must seriously weigh the cost: benefit ratio of consuming bone broth for health reasons.

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