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# Nutritional analysis of super galena hops

**Traditionally hops have been used as a minor constituent in the brewing of beer, as a result there has been little research into the nutritional components of this very important ingredient. Reported here, for the first time, is detailed comprehensive nutritional analysis performed on the hop variety, Super Galena.**

Descriptors: hops, nutrition, vitamins, minerals, fatty acids, protein, ash, calories, nitrogen free extract, fiber

## 1 Introduction

Unlike barley malt, when it comes to hops, there is little to no information reported in the literature regarding its nitrogen free extract, amino acid composition, crude fiber, ash, calories, vitamins, and minerals. Although there have been some publications which reported the protein concentration and amino acid composition of hops [1, 11, 12], some fatty acids analysis [5, 13], and a few minerals [7, 8, 9] there hasn't been reported any detailed analysis of these and other nutrients. Super Galena hop pellets were sent to NutriData, a Nutritional Analysis company, and analyzed for total protein, amino acid profile, nitrogen free extract, crude fiber, ash, calories, vitamins, minerals, and fatty acid profile. The results of these analysis are reported here along side nutritional analysis of barley malt reported by the U.S. Department of Agriculture [14].

## 2 Experimental

The methods used for the analysis mostly came from AOAC International. Test specifically performed were: Amino Acids – AOAC Acid Hydrolysis Extraction – AOAC 982.30 modified. Ash – AOAC 942.05. Calcium by ICP in Feed Samples – AOAC 965.17/985.01 modified. Calories calculated per AAFCO. Chloride Soluble – AOAC 969.10 modified. Choline Total – AOAC 999.14. Copper by ICP – AOAC 965.17 / 985.01 modified. Cystine & Methionine – AOAC 994.12 modified. Fat by acid hydrolysis – AOAC 954.02. Fatty acid profile, % by weight – AOAC Ce 2-66 AOAC Ce 1-62. Crude Fiber – AOAC 962.09. Folic Acid J. AOAC, Vol 73, No. 5, 1990 modified. Iodine – AOAC 932.21 or ICP-MS. Iron, Magnesium, Manganese, Phosphorus, Potassium, Sodium by ICP – AOAC 965.17 / 985.01 modified. Selenium – AOAC 986.15. Nitrogen Free Extract (NFE) – Feeds and Nutrition 1990 pp. 559. Protein – Combustion – AOAC 990.03, AOAC 992.15. Niacin – AOAC 944.13. Total Vitamin A – AOAC 974.29 modified. Tryptophan – AOAC 988.15. Vitamin B1 (Thiamine HCl) AOAC 942.23. Vitamin B12 – AOAC 952.20 / 45.2.02. Vitamin B2 (Riboflavin) AOAC 970.65. Vitamin B5 (Pantothenic Acid) AOAC 945.74 modified. Vitamin B6

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(Pyridoxine) AOAC 961.15. Vitamin D3 – preen 12821:2007 (Feb) modified. Vitamin E by HPLC – AOAC 971.30. Zinc by ICP – AOAC 965.17 / 985.01 modified.

## 3 Results and Discussion

The protein concentration of the Super Galena hop pellets assayed 14.5 %w/w, for malt 10.3 %. Following acid hydrolysis the amino acid composition as a percent of total weight showed the following amino acids and their concentration, see table 1.

The hop pellets also showed to contain 14.4 % Crude Fiber, 8.8 % Ash and the moisture measured 6.5%. The Crude Fat assayed 27.6 %, however, it should be noted that hops do not contain 27.6 % fat. The test for crude fat requires ether extraction of the hops followed by acid hydrolysis. Given the high concentration of alpha acids (~ 14 %), beta acids (~ 8 %), and hop oil (~ 2 %)

**Table 1 Amino Acids and their Concentration**

Amino Acid	Concentration In Hops	Concentration In Barley Malt
Alanine	0.47 %	0.52 %
Arginine	0.98 %	0.84 %
Aspartic acid	0.34 %	0.78 %
Cysteine	0.09 %	0.16 %
Glutamic Acid	0.86 %	1.82 %
Glycine	0.38 %	0.44 %
Histidine	0.24 %	0.27 %
Isoleucine	0.34	0.36 %
Leucine	0.55 %	0.74 %
Lysine	0.52 %	0.53 %
Methionine	0.12 %	0.29 %
Proline	0.42 %	1.12 %
Phenylalanine	0.38 %	0.22 %
Serine	0.42 %	0.46 %
Threonine	0.35 %	0.47 %
Tryptophan	0.14 %	0.13 %
Tyrosine	0.22 %	0.34 %
Valine	0.41 %	0.50 %
Total	14.5 %	10.3 %

in Super Galena hops, and the high solubility of these non-polar hop compounds in a solvent like ether means most of the crude fat comes from hop acids, hop oils, and a small amount coming from waxes, polyphenols, and fatty acids; so crude fat could not be determined.

Nitrogen Free Extract which is composed of digestible sugars, carbohydrates, vitamins and other non-nitrogen soluble organic compounds in hops assayed 28.1 % vs 71.3 % for barely malt. Nitrogen Free Extract is calculated [2] using the following formula:

$$\text{NFE} = 100\% - (\% \text{crude protein} + \% \text{crude fat} + \% \text{crude fiber} + \% \text{ash} + \% \text{moisture})$$

It should be noted that hops contain free sugars that are water soluble and fermentable. Wallerstein [3] was first to report that hops contain 3 – 4 %w/w sugars including glucose and fructose. Sugar analysis by MacWilliam [4] showed hops to contain a mixture of sugars including fructose, glucose, sucrose, raffinose with their total concentration being in the range of 2.5 – 3 %w/w.

Hops also contain vitamins, A, B, D and E in addition to B-carotene, a provitamin, a precursor to vitamin A, Choline, a water-soluble vitamin-like essential nutrient responsible for synthesis of phospholipids in cell membranes, methyl metabolism, and acetylcholine synthesis. Table 3 lists the vitamins found in hops along with their corresponding concentration.

Because vitamins A, D, and E are fat soluble it is unlikely much of these vitamins will dissolve into beer, however, the water-soluble B vitamins and Choline should.

Like all botanicals, hops contain a range of minerals. The ones detected are listed in table 4, along with their concentrations.

The fatty acid profile of hops as a percent of the total weight were:

0.01 % C8:0 Octanoic Acid (Caprylic), 0.04 % C10:0 Decanoic Acid (Capric), 0.02 % C11:0 Undecanoic Acid (Hendecanoic), 0.02 % C12:0 Dodecanoic Acid (Lauric), 0.01 % C14:0 Tetradeconoic Acid, < 0.01 % C14:1 Tetradecenoic Acid, < 0.01 % C15:0 Pentadecanoic Acid, < 0.01 % C15:1 Pentadecenoic Acid, 0.21 % C16:0 Hexadecanoic Acid (Palmitic), 0.02 % C16:1 Hexadecenoic Acid (Palmitoleic), 0.01 % C17:0 Heptadecanoic Acid (Margaric), < 0.01 % C17:1 Heptadecenoic Acid (Margaroleic), 0.04 % C18:0 Octadecanoic Acid (Stearic), 0.06 % C18:1 Octadecenoic Acid (Oleic), 0.34 % C18:2 Octadecadienoic (Linoleic), 0.34 % C18:3 Octadecatrienoic Acid (Linolenic), 0.02 % C18:4 Octadecatetrenoic Acid, 0.04 % C20:0 Eicosanoic (Arachidic), < 0.01 % C20:1 Eicosenoic (Gadoleic), 0.01 % C20:2 Eicosadienoic, < 0.01 % C20:3 Eicosatrienoic, < 0.01 % C20:4 Eicosatetraenoic (Arachidonic), < 0.01 % C20:5 Eicosapentaenoic, 0.4 % C21:5 Heneicosapentaenoic, 0.05 % C22:0 Docosanoic (Behenic), < 0.01 % C22:1 Docosenoic (Erucic), 0.02 % C22:2 Docosadienoic, 0.07 % C22:3 Docosatrienoic, < 0.01 % C22:4 Docosatetraenoic, 0.33 % C22:5 Docosapentaenoic, 0.03 % C22:6 Docosahexaenoic, 0.03 % C24:0 Tetracosanoic (Lignoceric), and 0.03 % C24:1 Tetracosenoic (Nervonic). Total Fatty Acids were calculated to be 2.16 %w/w. It has been reported that fatty acids C6 to C10 have little impact on beer foam, however, fatty acids C<sub>12</sub>, C<sub>14</sub>, C<sub>16</sub>, C<sub>18</sub>, C<sub>18:1</sub> and C<sub>18:2</sub>

**Table 2 Crude Fiber, Ash, Moisture and Fat Concentration in Hops and Barley Malt**

Component	Concentration In Hops	Concentration In Barley Malt
Crude Fiber	14.4 %	7.1 %
Ash	8.8 %	1.4 %
Moisture	6.5 %	8.2 %
Fat	–	1.8 %

**Table 3 Vitamins and their Concentration in Hops and Barley Malt**

Vitamin	Concentration in Hops	Concentration in Barley Malt
B-carotene	47 ug/100 g	11 ug/100g
Thiamine Hydrochloride (Vitamin B1)	0.135 mg/100 g	0.31 mg/100 g
Riboflavin (Vitamin B2)	0.737 mg/100 g	0.31 mg/100 g
Niacin (Vitamin B3)	4.43 mg/100 g	5.64 mg/100 g
Pantothenic acid (Vitamin B5)	2.35 mg/100 g	0.58 mg/100 g
Pyridoxine (Vitamin B6)	0.996 mg/100 g	0.65 mg/100 g
Folic Acid (Vitamin B9)	0.20 mg/100 g	0 ug/100
Vitamin B12	< 0.440 ug/100 g	0 ug/100
Cholecalciferol (Vitamin D3)	77.8 IU/100 g	0 ug/100
Tocopherols (Total Vitamin E)	18.7 IU/100 g	0.57 mg/100 g
Choline	1,110 ppm	100 ppm

**Table 4 Mineral and their Concentration in Hops and Barley Malt**

Mineral	Concentration in Hops	Concentration in Barley Malt
Calcium	0.74 %	0.037 %
Chloride-soluble	0.18 %	–
Copper	8 ppm	2.7 ppm
Iron	0.03 %	0.005 %
Magnesium	0.38 %	0.1 %
Manganese	54 ppm	12 ppm
Phosphorus	0.5 %	0.3 %
Potassium	2.43 %	0.22 %
Selenium	< 0.1 ppm	0.38 ppm
Sodium	0.01 %	0.01 %
Zinc	29 ppm	20 ppm
Iodine	< 0.1 ppm	–

can negatively impact beer foam, at concentrations as little as 2 mg/L [6, 10]. Malt on the other hand contains 0.92 % linoleic acid, 0.34 % palmitic acid, 0.25 % oleic acid and 0.15 % linolenic acid [15].

The calories for hops were calculated to be 3,839 Kcal/kg and 302 Kcal/Kg for barley malt by using the below formulas:

$$\text{Metabolized Energy} = [(3.5 \times \% \text{ crude protein}) + (8.5 \times \% \text{ crude fat}) + (3.5 \times \% \text{ nitrogen free extract})] \times 10$$

Where 14.5 % was used for crude protein, 27.6 % for crude fat, and 28.1 % was used for nitrogen free extract for hops and barley malt used 10.3 % protein, 1.84 % fat and 71.5 % nitrogen free extract.

Again, even though hops don't contain 27.6 % crude fat, calories are calculated by the heat energy produced by the oxidation of the organic compounds. Since this 27.6 % value includes alpha acids, beta acids, hop oils, etc. all are organic compounds 27.6 % was used. However, given that most of the crude protein will not dissolve into the beer and most of the crude fat is composed of alpha acids, beta acids and hop essential oils, and their concentrations in beer is in the ppm level means these components will contribute few calories to beer.

## 4 Conclusions

Nutritional analysis of Super Galena hop pellets show it contains by weight approximately 14.5 % protein, 14.4 % crude fiber, 8.8 % ash, 28.1 % nitrogen free extract, and 2.16 % fatty acids whereas barley malt contains 10.3 % protein, 7.1 % crude fiber, 1.4 % ash, 71.7 % nitrogen free extract and 1.84 % fatty acids. Hops also contain a range of B-vitamins including Folic Acid, Niacin, Thiamine, Vitamin B12, Riboflavin, Pantothenic acid, and Pyridoxine totaling 8.8 mg/100 g whereas malt contains a total of about 8.0 mg/100 g. Hops also contain Choline, a water-soluble vitamin like essential nutrient and trace amounts of the fat soluble vitamins A, D, and E. Hops also contain a range of minerals including potassium, calcium, magnesium, iron, sodium, and trace amounts of manganese, zinc, copper, as well as soluble chloride, phosphorous, selenium and iodine. Finally, because so little of the overall hop gets extracted into beer, the overall caloric contribution to beer is at best minimal.

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