The Food Analysis Of The Prickly Pear Cactus (Opuntia Polyacantha)

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THE FOOD ANALYSIS OF THE PRICKLY PEAR CACTUS (OPUNTIA POLYCANTHA)

by

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John D. Commerford
Stephen F. Jones

In partial fulfillment of the requirements for the Bachelor's Degree in Chemistry

CARROLL COLLEGE
HELENA, MONTANA
April 1, 1950
INTRODUCTION

The primary purpose of this thesis was to perform a food analysis of the prickly pear cactus (Opuntia Polycantha) in order to ascertain the percentage of the six basic constituent groups; (1) water or moisture, (2) fat, (3) protein, (4) crude fiber, (5) ash, (6) Nitrogen-free-extract.

Because the prickly pear cactus grows in profusion in Montana in areas otherwise useless for agriculture, a use for this plant as forage would be a distinct advantage to the farmers of the state. With this end in view we have initiated a series of analyses on the prickly pear cactus, by performing a food analysis to determine the feasibility of cactus as an emergency fodder for livestock.

An examination of the Chemical Abstracts from 1930-1949 reveals that no analytical work has been performed on the prickly pear cactus (Opuntia Polycantha).
I. COLLECTION AND PREPARATION OF SAMPLE

The cactus was gathered in August and September (1949) in an area within a twenty mile radius of Helena, Montana. It was stored in indirect light and exposed to the air from four to five months. The cactus was washed with brushes under running water, and the pears, spines, and roots were ground by hand in a meat grinder. The ground cactus was spread out in the dark, at room temperature, for one week and the air-dry sample was ground to very fine powder by repeated grindings in a coffee grinder.
II. DETERMINATION OF WATER OR MOISTURE

This determination was for water and any constituents volatile at 94.8°C and 655.5 mm mercury. This analysis was accomplished by passing dry hydrogen gas, generated by zinc and 20% sulfuric acid solution, through the sample. The hydrogen gas was first bubbled through a nearly saturated sodium hydroxide solution for purification, and then through concentrated sulfuric acid for dehydration. The gas, in passing through the sulfuric acid was bubbled over glass beads to give more surface for absorption of moisture. The powdered air-dry sample was placed in a weighed calcium chloride tube, both ends of which were loosely plugged with cotton. After the sample weight had been determined, the tube was connected to the hydrogen-generating apparatus, and placed in a jacket immersed in a boiling water bath. The analysis was carried out in a hood to remove the hydrogen exhaust. The hydrogen was passed through the sample for four hours, and the calcium chloride tube was then removed from the apparatus and weighed. The percentage of water was determined by difference.

On two trials, 7.72 and 7.19% water were determined. These figures gave 0.7% precision and an average of 7.54% water.
III. DETERMINATION OF FAT

An extraction process, using ether as a solvent, was used in the fat analysis. The percentage of fat, therefore, includes fat-soluble vitamins, pigments, sterols and lecithins as well as glycerides; i.e., all either-soluble material.

The fat extraction apparatus used was the Soxhlet extractor. The hydrogen-dry sample was placed in the felt thimble, and a weighed 150-ml. beaker containing 100 ml. of anhydrous diethyl ether was inserted in the metal base beneath the glass cup and siphon. The metal base was then placed in a water bath and the temperature of the bath was regulated so that a steady dripping of ether flowed from the reflux condenser to the felt thimble. The fat extraction was continued for four hours. The beaker was removed and the ether evaporated at 45° C. and the beaker and residue weighed. The weight of the residue (fat) was determined by difference.

In two trials, 2.32 and 2.25% fat were found. This gives 0.1% precision and an average of 2.28% fat.
IV. DETERMINATION OF PROTEIN

The Kjeldahl method was used for the determination of total nitrogen in the sample. This figure was converted to percent of crude protein by use of the 6.25 factor. Because of the possibility of a relatively high alkaloidal content in the cactus sample the Arnold copper sulfate macro modification of the Kjeldahl method was used.

Into a 600-ml. Kjeldahl flask were placed 1 gram of accurately weighed air-dry sample, 1 gram of mercuric oxide, 16 grams of potassium sulfate and 25 ml. of concentrated sulfuric acid. This mixture was digested until a clear solution was obtained. On cooling, the solution was diluted with 250 ml. of water and 25 ml. of 4% potassium sulfide solution was added to precipitate the copper and mercury. Nearly saturated sodium hydroxide solution was added while rotating and cooling the flask, until the mixture was alkaline to litmus. A pinch of finely granulated zinc was added to prevent bumping. The flask was attached to the distilling apparatus and distilled until 150 to 200 ml. of liquid passed over into

A measured excess of 0.1 N acid which had been previously added to the receiver. The acid solution was back-titrated with standard alkali using bromthymol blue indicator. From the equivalents of ammonium hydroxide calculated, the percentage of nitrogen was determined.

On two trials, this proved to be 0.721 and 0.784% nitrogen. By multiplying by the factor 6.25, the results 4.51 and 4.90% protein were obtained. This gives 4.2% precision and an average of 4.70% protein.
Crude fiber includes cellulose, lignin, pentosans, silica, sand, other mineral matter locked in the tissues, and a little nitrogenous matter. The method used was the Henneburg acid-alkali gravimetric method.³

The hydrogen-dry, fat free sample was weighed into a 500 ml. Erlenmeyer flask which was marked at the 200 ml. level. A solution of 1.25% sulfuric acid was heated to boiling and poured into the flask to the 200 ml. mark. This was immediately subjected to a low flame and was boiled for exactly 30 minutes. At the end of this time it was filtered and washed with hot water until the washings were neutral to litmus. Then the sample was washed off the filter paper into the original flask to the 200 ml. mark with 1.25% sodium hydroxide which had been heated to boiling. This sample was again subjected to a low flame and boiled for exactly 30 minutes. At the end of this period the sample was filtered on filter paper which had been previously weighed in a weighing bottle and dried in the oven at 100°C. The non-filterable matter was washed with hot water until the washings were neutral to litmus. It was then washed twice with

3. Ibid., p. 64
alcohol and three times with ether and allowed to dry at room temperature overnight.

The air-dry sample and filter paper were placed in the weighing bottle, dried in the oven at 100°C for three hours, cooled and weighed. Then the crude fiber and filter paper wereashed in a weighed crucible, and a blank determination of filter paper was run. From these combined weights, the weight and percentage of crude fiber were determined.

On two trials, 15.3 and 14.2% crude fiber were obtained. This gives 1.6% precision and an average of 14.8% crude fiber.
VI. DETERMINATION OF ASH

The double incineration method was used in this analysis.\(^4\)

Two grams of air-dry sample were placed in a weighed evaporating dish and ignited over a Bunsen burner at a heat below redness to a grey ash. Five ml. of water and a drop of nitric acid were added and the mixture was evaporated to dryness. The sample was then heated over the Bunsen burner for one hour, then in the muffle furnace at a heat below 500° C. From the weight of ash the total ash percentage was calculated.

On two trials, 14.0% and 14.3% ash were determined. This gives 0.9% precision and an average of 14.1% ash.

\(^4\) Ibid. p. 67
VII. DETERMINATION OF NITROGEN-FREE EXTRACT (NIFEXT)

The percentage of nitext was determined by totaling the average calculations for the percent of water, fat, protein, crude fiber and ash, and subtracting this sum from one hundred. Nifext represents approximately the starch, gums, sugars and organic acids (all nitrogen-free) which may be extracted by water or diastase from clean, dried and defatted foods.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>7.5%</td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>2.3</td>
<td>100.0</td>
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<tr>
<td>Protein</td>
<td>4.7</td>
<td>43.4</td>
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<tr>
<td>Fiber</td>
<td>14.8</td>
<td>56.6% Nifext</td>
</tr>
<tr>
<td>Ash</td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>43.4</td>
<td></td>
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</table>
COMPILATION OF DATA

Water or moisture .............. 7.5%
Fat ................................ 2.3%
Protein .......................... 4.7%
Fiber ............................... 14.8%
Ash ................................. 14.1%
Nifext. ............................ 56.6%

All percentages were computed on finely ground air-dry samples.
<table>
<thead>
<tr>
<th></th>
<th>DRY MATTER</th>
<th>PROTEIN</th>
<th>FAT</th>
<th>NITROGEN</th>
<th>FIBER</th>
<th>ASH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cactus</td>
<td>92.5</td>
<td>5.0</td>
<td>2.8</td>
<td>61.1</td>
<td>16.0</td>
<td>15.1</td>
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<tr>
<td>Forage crops</td>
<td>85.8</td>
<td>18.5</td>
<td>1.8</td>
<td>45.0</td>
<td>28.0</td>
<td>6.7</td>
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<tr>
<td>Wheat</td>
<td>89.4</td>
<td>13.1</td>
<td>2.1</td>
<td>80.0</td>
<td>2.7</td>
<td>2.1</td>
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<tr>
<td>Rye</td>
<td>86.6</td>
<td>13.8</td>
<td>2.1</td>
<td>80.4</td>
<td>1.6</td>
<td>2.1</td>
</tr>
<tr>
<td>Barley</td>
<td>90.7</td>
<td>14.7</td>
<td>2.0</td>
<td>83.9</td>
<td>6.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Corn</td>
<td>86.9</td>
<td>9.9</td>
<td>4.4</td>
<td>82.0</td>
<td>2.2</td>
<td>1.5</td>
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<tr>
<td>Oats</td>
<td>90.1</td>
<td>13.4</td>
<td>4.7</td>
<td>64.9</td>
<td>13.2</td>
<td>3.8</td>
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<tr>
<td>Buckwheat</td>
<td>87.3</td>
<td>11.5</td>
<td>2.5</td>
<td>74.0</td>
<td>9.2</td>
<td>2.3</td>
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<tr>
<td>Carrot</td>
<td>11.0</td>
<td>9.1</td>
<td>0.9</td>
<td>71.8</td>
<td>9.1</td>
<td>9.1</td>
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<tr>
<td>Cabbage</td>
<td>8.5</td>
<td>18.8</td>
<td>3.5</td>
<td>52.9</td>
<td>13.0</td>
<td>11.8</td>
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<tr>
<td>Bean, Lima</td>
<td>89.6</td>
<td>20.0</td>
<td>1.7</td>
<td>73.7*</td>
<td>....</td>
<td>4.6</td>
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<tr>
<td>Bean, Navy</td>
<td>87.4</td>
<td>25.7</td>
<td>2.1</td>
<td>63.2</td>
<td>5.0</td>
<td>4.0</td>
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<tr>
<td>Peas</td>
<td>25.4</td>
<td>27.2</td>
<td>1.1</td>
<td>63.5</td>
<td>5.0</td>
<td>3.2</td>
</tr>
</tbody>
</table>

* includes fiber

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5. Ibid p. 422.
6. Ibid p. 548
7. GRASS YEARBOOK OF AGRICULTURE p. 820 U.S Dept. Agriculture
The tables referred to above gave values in terms of the natural product in some instances and in others from a dried or partially dried sample. In order to have some basis for comparison, the results of these tables as well as the results of this analysis were converted to perfectly dry samples. It is from these results that this table has been derived.
EVALUATION OF DATA

Comparison of the results found in the analysis of the prickly pear cactus with results given in Table I for other foods reveals that in general, the cactus lies between cereal grains and vegetables for most of the constituents. As previously reported, the results for the prickly pear cactus are based on an air-dry sample. The fresh cactus obviously contains a high percentage of water. Therefore the fresh sample would contain corresponding higher percentages of non-volatile material. These discrepancies can be eliminated by basing all figures on a water-free sample as was done in Table I.

The percentage of water in the water fraction is therefore a relative fraction, depending on the conditions for drying.

The percentages of fat compares favorably with most of the foods listed. The highest deviation being that of Oats.

The protein content is the one diverging factor of the analysis, as the percentage of protein is lower than that found for other foods. The legume plants are particularly high in protein as is to be expected. There is some similarity in the protein content of the more succulent vegetables such as carrots.
The nifext present in cactus is sufficient to warrant its use as a food. This is evident from the fact that the percentage of nifext in forage crops is over 15% less than that of cactus.

The percentages of fiber and ash fall within the range of comparable foods. Fiber ranges from 1% in succulent fruits and vegetables to 37% in the hulls of bran and ash ranges from less than 1% in flours to 14% in rice hulls.\(^8,9\)

It may be concluded from the basic food analysis that the prickly pear cactus (Opuntia Polycantha) may, in an emergency be usefull as a feed for livestock. Many species of cactus have a notoriously high poisonous alkaloid content, a factor which was not considered in this analysis.\(^10\)

Need for detailed investigation of constituent groups is immediately evident. In conjunction with the food analysis, the determination of vitamin content is an important factor. Cactus might also be a source of vitamins for the manufacture of pharmaceuticals. Vitamins and alkaloids, another analyzable factor, may be

9. Ibid. p. 548
readily determined by chromatographic methods.\textsuperscript{11} The recent trend toward using antibiotics found in higher plants furnishes a wide and interesting field in work with cactus.

Appended is a list of useful references for further study of the constituents of the Opuntia Polycantha.

\textsuperscript{11} Strain, H. H. Chemical Analysis Vol. 2 (Chromatographic Adsorption Analysis) pp 101, 102
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