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Ronald Burns Hyde for the M.S. in Food Technology

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Title Studies Involving Proteolysis by Filbert Extracts

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STUDIES INVOLVING PROTEOLYSIS BY FILBERT EXTRACTS

It has been reported recently that extracts of filbert nuts demonstrate considerable proteolytic activity on a non-fat milk solids substrate. The addition of these extracts to cheddar cheese, in an attempt to enhance the rate of ripening, has been suggested.

In these experiments, the extracts of two varieties of filbert nuts, i.e. Du Chilly and Barcelona, were added to cheddar cheese samples at the milling stage of manufacture. The rate of proteolysis, in the cheese samples, was determined quantitatively by the increase in soluble protein content over a three month period. At the termination of these experiments a taste evaluation was performed on all cheese samples.

A statistical analysis on the results of the soluble protein analyses showed that the proteolysis in the treated cheese samples was significantly greater than the proteolytic breakdown in the control samples. A defatted extract of Barcelona variety of filbert nuts was the most effective treatment for enhancing the proteolysis in the cheese samples. The results of the taste tests showed that no significant improvement in the flavor of the cheese resulted from the addition of filbert extracts.

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the requirements for the degree of

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Date thesis is presented June 1951

Approved by Louis H. Mufar
STUDIES INVOLVING PROTEOLYSIS BY FILBERT EXTRACTS

by

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</tr>
<tr>
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</tr>
</tbody>
</table>
STUDIES INVOLVING PROTEOLYSIS BY FILBERT EXTRACTS.

INTRODUCTION

The filbert nut is a very important orchard crop in the state of Oregon. At the present time this state is responsible for eighty-seven per cent of the total filbert production of the entire United States.

During the last two decades, the increase of filbert nut production in Oregon has been phenomenal. The following statistics demonstrate the rapid expansion of this industry (20, p. 8):

<table>
<thead>
<tr>
<th>Period</th>
<th>Farm Production in Oregon</th>
</tr>
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<tbody>
<tr>
<td>1930 to 1934</td>
<td>602 tons</td>
</tr>
<tr>
<td>1935 to 1939</td>
<td>2108 tons</td>
</tr>
<tr>
<td>1940 to 1944</td>
<td>4600 tons</td>
</tr>
<tr>
<td>1945 to 1949</td>
<td>6920 tons</td>
</tr>
</tbody>
</table>

The return of large European imports after the second world war, together with the increased domestic production, has stimulated the search for new uses for the surplus of this crop.

The recent discovery that extracts of filbert nuts are capable of enhancing the proteolysis in non-fat milk solids (21) has led to applications of possible commercial significance. One such application is the reported reduction in the ripening period of cheddar cheese to which these extracts have been added.
The study of the effect of filbert extracts on cheddar cheese has consisted entirely of organoleptic analyses up to the present time. It appears logical that the development of an objective chemical test for determining the proteolytic action of these extracts would be of value. It may be stated, therefore, that the purpose of this experimental work is to determine quantitatively the extent of proteolysis in ripening cheddar cheeses which have been treated with filbert extracts, and to attempt a correlation between the amount of proteolysis and the flavor score as determined by a preferential taste evaluation.
LITERATURE SURVEY

I. PROTEOLYTIC ENZYMES IN PLANTS

The presence of proteolytic enzymes in many plants has long been known. According to Balls (4, pp.1-9), the occurrence of a meat digesting enzyme in the juice of the pineapple was noted as early as 1891. The same worker reported the presence of a protein digesting enzyme in the leaves and green fruit of the papaya tree (Carica Papaya).

Proteolytic enzymes in the fig, lima bean and wheat kernel have also been reported (29, pp.308-310), (10, pp.613-619) and (5, pp.622-623).

The fact that extracts of the kernels of filbert nuts show considerable proteolytic activity has been shown recently by Parpia (21). A non-fat milk solids substrate was used to demonstrate this activity.

II. PROTEOLYSIS OF CHEDDAR CHEESE

Ripening cheddar cheese passes through a series of physical and chemical changes which cause it to lose its elastic properties and to become soft and mellow. One of the most important causes of these changes is the gradual breakdown of the insoluble protein to a soluble form. A survey of the literature on the subject reveals that the proteolysis of cheddar cheese is brought about by
proteolytic enzymes from two main sources, namely: those elaborated by bacteria and those added with the rennet.

It might be well to clarify the term "rennet" at this point. Rennet is the commercial name for a preparation obtained from the so-called fourth stomach (abomasum) of young calves and lambs and consists primarily of the enzyme rennin, although it is seldom free of the enzyme pepsin (23, p.215).

On the basis of his investigations on the proteolysis of cheddar cheese, Kelly (16, pp.229-230) concludes that the enzyme galactase, indigenous to the milk, pepsin from the rennet and enzymes elaborated by bacteria are the causes of the breakdown of the insoluble protein to peptone, polypeptides and finally to amino acids and ammonia. He further reports that *Streptococcus lactis*, *Streptococcus cremoris* and *Lactobacillus casei* are the most active bacteria causing the proteolysis.

Boekhout (7, pp.330-336) believes that the lactic acid bacteria affect the proteolysis of cheddar cheese in the following manner:

1. The endoenzymes which are liberated when the dead bacteria disintegrate probably have an influence.

2. The acid which they produce creates conditions favorable for the action of enzymes introduced with the rennet.
The views of Van Slyke, Harding and Hart (23, p.246) correspond with those of Boekhout in that they found that neither the rennin enzyme nor commercial pepsin produces proteolysis in the absence of acid, but either is proteolytic when acid is present.

Dean and Freeman (12, p.57) are of the opinion that the rate of proteolysis is directly related to the number of proteolytic bacteria initially found in the cheese. They further report that the addition of supplementary amounts of rennet hastened the ripening of cheddar cheese. The addition of small quantities of pepsin or trypsin had a similar effect on proteolysis. Harvesson (15, pp.500-517), working with Russian Limburger cheese, noted that supplementary rennin stimulated the rate of protein breakdown.

According to Peterson, Johnson and Price (22, pp.55-61), the active proteinase in ripening cheddar cheese is largely of bacterial origin with only a small amount of the total activity being contributed by the rennet. Similar views are held by Allen and Knowles (2, pp.185-196), who recommend a vigorous starter of lactic acid streptococci to stimulate proteolysis, and by Davis, Dearden and Mattick (11, pp.144-152), who advocate adding lactobacilli as well as lactic acid streptococci in the starter.

Sherwood and Whitehead (26, pp.208-222) hold a view
on cheddar cheese ripening that conflicts with the opinions of many of the other workers in this field. They believe that the rennet enzymes are the main cause of proteolysis and that the function of the lactic acid streptococci, present in the early stages, is merely the formation of acid which stimulates the rennet enzymes. In earlier work, Sherwood (25, pp. 204-217) offered evidence to support this theory. He eliminated the bacterial flora of cheese samples by the addition of chloroform and added supplementary quantities of rennet to overcome the effect of the germicide. He found that the protein degradation, as measured by soluble nitrogen and non-protein nitrogen, was identical with that in the normal control cheese. However, no volatile acid was present, and therefore he assumed that there was no cheese flavor.

The changes in the protein of cheddar cheese during aging have been studied in some detail. As early as 1921 Barthel and Rosengren (6, p. 16) realized the necessity for developing an objective test for determining the stages of ripening. They suggested analysis based not only on soluble protein, which indicates the extent of proteolysis, but also on volatile acid, which reveals the amount of flavor. They further state that, in general, the amount of water-soluble nitrogen in ripe cheese constitutes at least 30 per cent of the total nitrogen, and
a cheese that contains this amount may be considered ripe.

Eagles and Sadler (13, pp.227-240), working with Kingston cheese, reported a marked increase in water-soluble nitrogen content during the ripening period.

Dahlberg and Kosikowski (9, pp.165-174) made extensive analysis of ripening cheddar cheeses and found a direct relationship between the age and the soluble protein content. They studied cheeses of two to fourteen months of age and found the soluble protein varied from 4.53 per cent to 8.88 per cent. However, no correlation could be noted between soluble protein and the intensity of flavor.

Sandelin (24, pp.497-503) found that the ripening of cheese represents a breakdown of casein to low molecular proteins or amino acids. The rate of ripening can thus be determined by the progressive increase of carboxyl and amino groups in the cheese.

Allen (1, pp.38-67) believes that the extent of protein degradation of cheddar cheeses can best be measured by a formaldehyde titration of the nitrogen which is soluble in 80 per cent alcohol.

Tuckey, Ruehe and Clark (27, pp.777-789) studied the cheese ripening process by X-ray diffraction analysis. By extraction of aged cheese with n-butyl alcohol, several amino acids were obtained and identified.
Harper and Swanson (14, pp.147-154) used microbiological assay techniques to identify nine amino acids in ripening cheddar cheese. They noted a very close relationship between the amino acid concentration and the flavor intensity. Evidence was also presented to demonstrate that the water-soluble nitrogen content closely paralleled the amount of flavor. Another experiment in which amino acids were added to bland bases and then judged organoleptically, definitely indicated that the amino acids are related to cheese flavor.

In a recent publication, Kosikowski (17, pp.235-241) states that, at the present time, it is hazardous to evaluate the role of free amino acids in the development of the typical cheddar flavor. He believes that the reason for this difficulty is not only that some amino acids are produced more rapidly than others, but also that some may decrease in concentration after the cheese ripening reaches a certain stage. He further states that, in general, the increase in total free amino acids parallels the increase in flavor.

Since the primary purpose of this thesis is to determine the effect of filbert extracts on the proteolysis of cheddar cheese, it might be well to mention the preliminary work on this study. Parpia (21) conducted organoleptic tests on cheddar cheese samples which had been treated
with filbert extracts and reported indications of an accelerated ripening period resulting from such treatment.
EXPERIMENTAL PROCEDURES

I. PREPARATION OF FILBERT EXTRACTS

The extracts of filbert nuts were prepared by the method of Parpia (21). Two varieties of the nuts were used, namely: Du Chilly and Barcelona.

A 550 gram sample of filbert nuts was crushed in a meat grinder using the smallest disc. A 500 gram portion of the finely ground nuts was soaked for two hours in one liter of ten per cent sodium chloride solution. The mixture was transferred to a cheesecloth bag and pressed in a small mechanical press. The extract was filtered through a double layer of cheesecloth and stored at one degree C overnight. By means of a 50 ml pipette, the non-fat portion was separated from the top fatty layer.

II. PREPARATION OF TREATED CHEESE SAMPLES

Five 6 lb. samples of cheddar cheese curd were removed from a commercial vat immediately after milling. Each sample was placed in a five gallon milk container which was immersed in a water bath at 96°C degrees F. The cheese was stirred for 15 minutes and the filbert extracts were added to the respective samples as follows:

A. Using Du Chilly Extract

1. 100 ml of defatted extract in 10 per cent
NaCl solution.

2. 100 ml of total extract in 10 per cent NaCl solution.

B. Using Barcelona Extract

1. 100 ml of defatted extract in 10 per cent NaCl solution.

2. 100 ml of total extract in 10 per cent NaCl solution.

C. Control - no treatment.

The samples were stirred for ten more minutes and then salt was added at the rate of 74 grams to each experimental sample and 84 grams to the control. Stirring was continued for five more minutes to incorporate the salt and then the samples were placed in five lb. hoops or forms. The cheese was pressed for one hour, then removed, wrapped in cloth and pressed in the hoops again for a period of three hours. The samples were coded, waxed and then stored at 45 degrees F.

Two sets of samples were made up at different times in order to duplicate the experiment and thereby offer more conclusive evidence as to the reproducibility of the results obtained. Two sets of samples are referred to as Group A and Group B.
ANALYTICAL PROCEDURES

I. METHOD OF TAKING SAMPLES FOR ANALYSIS

The official Association of Official Agricultural Chemists method (3, p.262) was followed. A plug was taken with a cheese trier perpendicularly to the surface of the cheese. The rind was rejected and the remaining sample placed in a 150 ml beaker. The sample was cut finely and mixed thoroughly.

II. METHOD OF DETERMINING MOISTURE CONTENT

The official Association of Official Agricultural Chemists method (3, p.262) was used. A two to three gram sample was weighed into a metal dish which, after being covered loosely, was placed in a vacuum oven kept at 100 degrees C. The sample was dried to a constant weight at a pressure not exceeding four inches of mercury. A slow current of air, dried by passing through sulphuric acid, was admitted into the oven during drying. After drying, the dishes were removed, tightly covered, cooled and reweighed.

Moisture analyses were performed on all cheeses after two and ten weeks of ripening to determine not only the differences between samples, but also whether any detectable moisture loss occurred during the experimental period.
The method used for the peptization of the cheese protein is a modification of the procedure for the quantitative separation of filth in cheese products (3, p. 707). It involves the dissolving of the cheese protein in a 15 per cent solution of sodium citrate at a fairly high temperature (60 degrees C).

A ten gram cheese sample was weighed on an accurate balance and then placed in a porcelain mortar. A small amount of 15 per cent sodium citrate at 60 degrees C was added and the cheese was ground to a thick paste. Additional solution was added to dilute the sample, i.e. a total of 40 ml. The cheese solution was transferred to a 100 ml volumetric flask. The mortar was then washed with two successive 15 ml portions of the extracting solution. The flask was filled to the mark with the hot sodium citrate solution and then placed in a water bath at 60 degrees C for one hour. The flask was then rapidly cooled to 20 degrees C and cold 15 per cent sodium citrate solution was added to bring the volume back to 100 ml.

A 50 ml aliquot of the cheese solution was withdrawn and 25 ml of 1 normal trichloroacetic acid was added to precipitate the insoluble protein. The insoluble protein was removed by filtration. The filtrate was collected and used for the soluble protein analysis.
IV. METHODS OF ANALYSIS FOR SOLUBLE PROTEIN

A. THE SEMI-MICRO KJELDAHL TECHNIQUE

The method employed for the estimation of soluble protein was the semi-micro Kjeldahl technique. The many recent improvements in this technique, as outline by Cole and Parks (8, p.61), were made use of in this analytical work. These improvements include:

1. The highly efficient digestion catalysts of the mercury selenium type.
2. The boric acid method adapted to the semi-micro scale.
3. An improved indicator for use in the presence of boric acid (0.1 per cent bromocresol green and 0.1 per cent methyl red in the ratio of five to one).

The above suggested procedure was employed with one modification. During distillation of the digested samples, heat was supplied by a Bunsen burner rather than by steam. To allow for this modification, an increased amount of distilled water, i.e. 40 ml, was added to the flasks before distillation.

The analysis for soluble protein was performed on duplicate ten ml samples of the filtrate obtained after the precipitation and removal of the insoluble protein.
B. THE MODIFIED FORMOL TITRATION

The modification of Melnick and Oser (19, pp. 57-71) was employed. This method was later abandoned because of the lack of reproducibility in the results due to the strong buffering action of the cheese extracting solution (15 per cent sodium citrate) in the critical pH range, i.e. around pH 7.0.

V. METHOD OF PERFORMING PREFERENTIAL TASTE TESTS

The method of Lorant and Wiegand (18, pp. 1-3) was followed. Four samples were used for each evaluation. Two of the four samples were duplicates.

Group A and Group B samples were tested separately. The results of the judges, who did not detect the duplicated in Table IIIa and illustrated in Figures I, II, III and IV, indicate a progressive increase in soluble protein content for all samples throughout the entire experiment. The results of the soluble protein analyses (Table IIIa) indicate a progressive increase in soluble protein content for all samples throughout the entire experiment. It may be observed (Table IIIa) that, in general, the samples treated with filbert extracts show more proteolysis than the control samples, as evidenced by the higher soluble protein content. All of the cheese samples treated with defatted filbert extracts show a more rapid proteolytic breakdown in the early stages of ripening (Figures I
RESULTS AND DISCUSSION

I. MOISTURE CONTENT OF THE CHEESE SAMPLES

The analytical results for moisture content of the cheese samples are tabulated in Table I. There were only slight differences in the moisture content between any of the cheese samples. Also, there was no detectable loss in moisture content over the period of the experiment for any of the samples. The fact that the cheese samples were kept well coated with wax no doubt minimized any moisture changes.

II. SOLUBLE PROTEIN CONTENT OF THE CHEESE SAMPLES

The analytical results for soluble protein are tabulated in Table IIa and illustrated in Figures I, II, III and IV.

The results of the soluble protein analyses (Table IIa) indicate a progressive increase in soluble protein content for all samples throughout the entire experiment.

It may be observed (Table IIa) that, in general, the samples treated with filbert extracts show more proteolysis than the control samples, as evidenced by the higher soluble protein content. All of the cheese samples treated with defatted filbert extracts show a more rapid proteolytic breakdown in the early stages of ripening (Figures I
RESULTS

TABLE I

MOISTURE ANALYSES OF CHEESE SAMPLES

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Moisture Content in Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group A*</td>
</tr>
<tr>
<td>Defatted Du Chilly Extract</td>
<td>36.46</td>
</tr>
<tr>
<td>Defatted Barcelona Extract</td>
<td>37.38</td>
</tr>
<tr>
<td>Total Du Chilly Extract</td>
<td>36.57</td>
</tr>
<tr>
<td>Total Barcelona Extract</td>
<td>36.98</td>
</tr>
<tr>
<td>No Treatment (Control)</td>
<td>36.70</td>
</tr>
</tbody>
</table>

* Group A refers to the original set of treated samples.
** Group B refers to another set of identically treated samples which were prepared at a later date.

N.B. The above results were obtained on the cheese samples after aging them for two weeks. A repetition of the moisture analyses after ten weeks failed to reveal any detectable loss in moisture.
and II) than the samples treated with total filbert extracts (Figures III and IV).

It may also be noted (Table IIa) that at the end of the two week period, the soluble protein content for the Group B samples was roughly 0.5 per cent higher than similarly treated Group A samples, and that this proportionate lead was maintained throughout the entire analytical period. Thus, Group B samples showed approximately the same percentage of soluble protein at the ten week period as similarly treated Group A samples did after twelve weeks of ripening.

A statistical analysis of variance was performed on the results of the soluble protein analyses to determine whether the increase in proteolysis shown by the treated samples was significant. The method used was a two way classification with equal numbers of observations. In the analysis of variance, the age of the cheese samples was considered as one of the variables and the treatment as the other variable.

Each group of samples (A and B) was statistically analyzed separately at the five per cent level of significance.

The analysis of variance was performed on the mean percentages of soluble protein as tabulated in Table IIIb.

From the results of the statistical analysis it may
be concluded, with a 95 per cent degree of accuracy, that all of the cheese samples to which filbert extracts were added showed significantly greater proteolysis than the untreated control samples within the same group. It may also be stated that the samples treated with defatted Barcelona extract showed the greatest proteolytic breakdown.

The results of these experiments showed that the proteolysis of cheddar cheese may be enhanced by the addition of extracts of filbert nuts, even though the cheese ripening temperature (45° F or 7.2° C) was far below the optimum for enzyme action. Parpia (21) has demonstrated that the proteolytic action of filbert extracts on non-fat milk solids is comparatively low at 10° C and that the optimum temperature for the proteolytic activity is 37° C. Perhaps if the cheese had been ripened at a slightly higher temperature, the proteolytic effects of the extracts might have been more pronounced. It is realized, however, that there is a limit to the increase in temperature at which cheddar cheese may be ripened without encountering deleterious effects. Wilson, Hall and Johnson (23, pp.119-177) found that cheddar cheese, made from milk of good quality, can be ripened at temperatures as high as 50° F with reasonable certainty of developing a clean and characteristic cheddar flavor. The temperature suggested by these workers is only five degrees higher than the one used in these experiments, and it is doubted if such a small increase would have much effect.
### TABLE IIa

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Group A Samples</th>
<th>Group B Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weeks 2 4 6 8 10 12</td>
<td>2 4 6 8 10</td>
</tr>
<tr>
<td>1</td>
<td>2.08 3.25 3.62 4.02 4.82 5.13</td>
<td>2.55 3.62 4.19 4.82 5.13</td>
</tr>
<tr>
<td>2</td>
<td>2.21 3.48 3.82 4.09 4.69 5.29</td>
<td>2.61 3.72 4.35 4.86 5.42</td>
</tr>
<tr>
<td>3</td>
<td>2.21 3.07 3.48 4.05 4.62 5.13</td>
<td>2.28 3.42 4.07 4.82 5.06</td>
</tr>
<tr>
<td>4</td>
<td>1.94 2.86 3.62 4.15 4.69 5.29</td>
<td>2.58 3.42 4.07 4.76 5.16</td>
</tr>
<tr>
<td>5</td>
<td>2.01 2.83 3.42 3.82 4.26 4.79</td>
<td>2.41 3.33 5.89 4.62 4.92</td>
</tr>
</tbody>
</table>

**Treatments**

1 - Defatted Du Chilly Extract  
2 - Defatted Barcelona Extract  
3 - Total Du Chilly Extract  
4 - Total Barcelona Extract  
5 - No Treatment (Control)
TABLE I

Mean Percentages of Soluble Protein for Each Treatment of the Cheese Samples

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defatted Du Chilly Extract</td>
<td>3.820²</td>
<td>4.062</td>
</tr>
<tr>
<td>Defatted Barcelona Extract</td>
<td>3.930</td>
<td>4.192</td>
</tr>
<tr>
<td>Total Du Chilly Extract</td>
<td>3.760²</td>
<td>3.930</td>
</tr>
<tr>
<td>Total Barcelona Extract</td>
<td>3.758²</td>
<td>3.998</td>
</tr>
<tr>
<td>No treatment (control)</td>
<td>3.522</td>
<td>3.853</td>
</tr>
</tbody>
</table>

² These three means were found to be equal in the statistical analysis of variance. All of the other means within a group of samples (A or B) were found to be significantly different.

N.B. The standard deviation was 0.127 for Group A samples and 0.0853 for Group B samples.
THE EFFECT OF DEPAI$ED DU CHILLY EXTRACT ON PROTEOLYSIS

FIGURE 1

PERCENT SOLUBLE PROTEIN

AGE OF CHEESE IN WEEKS
THE EFFECT OF DEPATTED BARCELONA EXTRACT ON PROTEOLYSIS

FIGURE II

DEPATTED BARCELONA EXTRACT

CONTROL

GROUP 1 SAMPLES

GROUP 2 SAMPLES

PERCENT SOLUBLE PROTEIN

AGE OF CHEESE IN WEEKS
THE EFFECT OF TOTAL DU CHILLY EXTRACT ON PROTEOLYSIS

PERCENT SOLUBLE PROTEIN

AGE OF CHEESE IN WEEKS
THE EFFECT OF TOTAL BARCELONA EXTRACT ON PROTEOLYSIS

FIGURE IV

PERCENT SOLUBLE PROTEIN

AGE OF CHEESE IN WEEKS

TOTAL BARCELONA EXTRACT

CONTROL

SAMPLE A

SAMPLE B
III. PREFERENTIAL TASTE TESTS

The results of the taste tests are tabulated in Table IV.

Enough of the judges selected the duplicates in all of the taste evaluations to give validity to each test (Table III).

From the results (Table IV) it may be observed that the difference between the average score points, for all of the taste tests, was less than one point.

A statistical analysis of variance showed that there was no significant preference for any of the cheese samples used in those tests. This applied to both groups of cheese samples which were analyzed separately.
The following method (Table III) was used for testing the validity of the tasters' scores:

**TABLE III**

<table>
<thead>
<tr>
<th>Number of Judges Detecting Duplicates</th>
<th>Number of correct judgments needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>4</td>
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<tr>
<td>9</td>
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<tr>
<td>10</td>
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<td>11</td>
<td>5</td>
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<td>12</td>
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<td>14</td>
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<td>15</td>
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<td>17</td>
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<td>7</td>
</tr>
<tr>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>20</td>
<td>7</td>
</tr>
</tbody>
</table>

* Courtesy of Dr. Jerome C. R. Li, Biometrician, Oregon Agricultural Experiment Station.

M-number of judges
M-number of correct judgments needed
The taste tests (Table IV) were scored by the following system:

10 - ideal
9 - excellent
8 - very good
7 - good
6 - fairly good
5 - acceptable
4 - fair
3 - poorly fair
2 - poor
1 - very poor
0 - repulsive

**TABLE IV**

**Average of the Scores for All Taste Tests**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Group A Samples</th>
<th></th>
<th>Group B Samples</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>No. of Valid</td>
<td>Average</td>
<td>No. of</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>Scores</td>
<td>Flavor</td>
<td>Scores</td>
<td>Flavor</td>
</tr>
<tr>
<td>Defatted Du Chilly Extract</td>
<td>14</td>
<td>7.93</td>
<td>11</td>
<td>7.36</td>
</tr>
<tr>
<td>Defatted Barcelona Extract</td>
<td>14</td>
<td>7.64</td>
<td>12</td>
<td>7.75</td>
</tr>
<tr>
<td>Total Du Chilly Extract</td>
<td>13</td>
<td>7.15</td>
<td>15</td>
<td>7.73</td>
</tr>
<tr>
<td>Total Barcelona Extract</td>
<td>13</td>
<td>7.08</td>
<td>16</td>
<td>7.56</td>
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<tr>
<td>No Treatment (Control)</td>
<td>27</td>
<td>7.56</td>
<td>27</td>
<td>7.53</td>
</tr>
</tbody>
</table>
CONCLUSIONS

1. The addition of filbert extracts to cheddar cheese resulted in a significantly greater proteolytic breakdown as evidenced by a higher soluble protein content in the treated samples than in the control samples.

2. A defatted extract of Barcelona variety of filbert nuts was the most effective treatment for enhancing the proteolysis of cheddar cheese.

3. Treatment of cheddar cheese with filbert extracts did not result in any significant difference in the flavor.
BIBLIOGRAPHY


