THESIS

on

THE PLURAL NATURE OF VITAMIN B IN THE POTATO

Submitted to the

OREGON STATE AGRICULTURAL COLLEGE

In partial fulfillment of
the requirements for the
Degree of

MASTER OF SCIENCE

by

Lydia Tarrant

June 3, 1929
APPROVED

Professor of Foods and Nutrition
In Charge of Major

Chairman of Committee on Graduate Study
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Historical</td>
<td>1</td>
</tr>
<tr>
<td>Nomenclature</td>
<td>2</td>
</tr>
<tr>
<td>Proof of the Complex Nature of Vitamin B</td>
<td>3</td>
</tr>
<tr>
<td>Distribution</td>
<td>3</td>
</tr>
<tr>
<td>Solubility</td>
<td>4</td>
</tr>
<tr>
<td>Effect of heat</td>
<td>4</td>
</tr>
<tr>
<td>Effect of acids</td>
<td>4</td>
</tr>
<tr>
<td>Stability to alkalis</td>
<td>5</td>
</tr>
<tr>
<td>Experimental</td>
<td>6</td>
</tr>
<tr>
<td>Animals</td>
<td>6</td>
</tr>
<tr>
<td>Purification and Preparation of Constituents</td>
<td></td>
</tr>
<tr>
<td>of Basal Diet</td>
<td>7</td>
</tr>
<tr>
<td>Casein</td>
<td>7</td>
</tr>
<tr>
<td>Dextrinized starch</td>
<td>8</td>
</tr>
<tr>
<td>Butterfat</td>
<td>8</td>
</tr>
<tr>
<td>Salt mixture</td>
<td>8</td>
</tr>
<tr>
<td>Other constituents</td>
<td>9</td>
</tr>
<tr>
<td>Source of Vitamin B Factors</td>
<td>9</td>
</tr>
<tr>
<td>Separation of factors $P$ and $G$</td>
<td>9</td>
</tr>
<tr>
<td>Plan of experiment</td>
<td>12</td>
</tr>
<tr>
<td>Discussion</td>
<td>16</td>
</tr>
<tr>
<td>Conclusions</td>
<td>20</td>
</tr>
<tr>
<td>Bibliography</td>
<td>22</td>
</tr>
</tbody>
</table>
Photographs .................................................................

Height Charts ............................................................
THE PLURAL NATURE OF VITAMIN B IN THE POTATO

INTRODUCTION

Accumulative evidence due to recent investigations indicates the necessity of revaluation of foods in regard to their vitamin B content. Reviewing former studies, evidence of two factors of vitamin B is noted; one an antineuritic factor, and a second, frequently referred to as a growth promoting factor.

Historical

Emmet and Luens (2) fed autoclaved rice to rats on a diet lacking in the growth promoting factor, with the result of immediate gains, but when fed to pigeons, polyneuritis developed, indicating a distinction between the two factors. Sherman and Spohn (6) working with dried whole milk and ground whole wheat, and Sherman and Gross (5) testing tomato juice observed similar results. Smith and Hendricks (16, 18, 27) were the first to give satisfactory evidence of the dual nature of vitamin B when they compared a vitamin B picrate as a source of the antineuritic factor, with autoclaved yeast as a source of the growth promoting factor, supplementing a diet in which oat kernel or casein was the sole source of protein and vitamin B. Rats on the basal diet plus 2% vitamin B picrate showed no gain but when 5% autoclaved yeast was added, growth resulted. If autoclaved yeast was given without the vitamin B picrate, the
animals died. In more recent studies by Goldberger (12) rats were fed a diet producing symptoms similar to pellagra in humans. When fed Seidell’s fuller’s earth extract as a source of the growth promoting factor, rats immediately improved. Rats fed a basal diet with either autoclaved yeast or 40% extract of cornmeal declined in weight and died; but when fed small amounts of each, the animals grew. Salmon (22) found the seeds of the soy beans and velvet beans to be rich sources of the antineuritic factor and poor in the growth promoting factor, while the leaves were rich in the growth promoting vitamin and poor in the antineuritic. Chick and Rocce (35) noted that commercial caseinogen furnished the growth promoting factor for when a diet containing commercial caseinogen as a source of protein and Vemite, an English commercial yeast, as a source of the antineuritic factor, was fed to rats, animals grow, but when purified caseinogen was used, animals declined in weight and developed skin lesions typical of pellagra. Palmer and Kennedy (29) working with highly purified food stuffs in a synthetic diet give evidence that autoclaved yeast supplied the missing constituent in their ration. Wheat grain and corn grain are poor in the growth promoting factor but rich in the antineuritic factor as found by Hunt. (28)

HOMENCLATURE Sherman and Axthelm (23, 35) use
the letter F to designate the antineuritic factor and G as the growth promoting factor. The F factor of Sherman is identified with the B-P (beri-beri preventive) vitamin of Salmon (22) and the G factor with Goldberger's P-P vitamin. Goldberger (12) has suggested that the water soluble antineuritic factor be known as vitamin B and the pellagra preventive factor as P-P. Chick and Roscoe (35) use the same vitamin B for the two factors with B¹ for the antineuritic factor and B₂ for the growth promoting, antipellagric factor. Mc Collum (35) has given the name vitamin B to the antineuritic factor and vitamin F to the growth promoting, antipellagric factor. In this paper the terminology suggested by Sherman will be followed, namely--F to designate the antineuritic factor and G the growth promoting, antipellagric factor.

Proof of the Complex Nature of Vitamin B

Distribution

Mitchell (1) in a review of previous literature observed that the two factors of vitamin B were distributed in similar foods but not in equal quantities. Spinach and cabbage are rich sources of vitamin G compared to whole cereals, but cabbage contains a small amount of vitamin F as compared to whole grain cereals. Onions contain the G factor but no F. Green vegetables are moderately rich in G but contain little or none of the F factor (47). Salmon (22) found the seeds of
the soy bean and velvet bean to be richer in the antinou-
ritic factor than the leaves which were rich in G but
lacking in F.

Solubility. Coborne and Kendal (1) and Drummond
(1) believe the G factor to be insoluble in absolute alco-
hol while McGregor and Simmonds believe it to be incom-
pletely soluble in 95% alcohol, and the F factor readily
soluble. Tikitiki (26), an alcoholic extract of rice pol-
ishings, is almost lacking in vitamin G but rich in vita-
min F as shown by experiments on rats. Palmer and Kennedy
(29) found an alcoholic extract of wheat in an otherwise
vitamin B free diet furnished the F but not the G factor.
Both factors are soluble in water and can be dialized.
(17) Vitamin G is less soluble in strong alcohol and
benzene than vitamin F. Both are adsorbed upon animal
charcoal or fuller's earth but more completely in the case
of F.

Effect of heat. There is no appreciable loss of
either factor when heated to a temperature of 100°C. for
one to two hours but when the temperature is increased to
120°C, there is a marked destruction of F (1, 5, 17, 24,
27, 43).

Effect of acids. The solubility of both factors
in acids is great (1). "The vitamin activity of Karmite,
a commercial yeast, was not greatly diminished after boil-
ing for twelve hours in 1½ hydrochloric acid. When hy-
drolyzed at boiling temperature for ten hours with 20% sul-
phuric acid, the preparation showed greatly decreased power to promote growth. This was perhaps due to adsorp-
tion of the vitamin on barium sulphate during the removal of the acid by baryta rather than from destruction.² (44)

Stability to alkalies In contrast to its resis-
tance to acids, the vitamin B complex appears to be ex-
tremely sensitive to alkalies, especially with the appli-
cation of heat. Sherman and Burton (15) found the destruction to be greater by increasing the alkalinity than by raising the temperature. Osborne and Leavensworth (44) conclude the antineuritic activity is not materially affected in dilute alkaline solutions at a low temperature for a short exposure.

The potato has been chosen for the study of the plural nature of vitamin B because of its nutritive value and universal use. It is predominantly a carbohydrate food, but also contains protein of good biological value (49, 50) as proven by Kon in his experiments with adult men and women fed on potato as their sole source of pro-
tein over a period of 167 days. In regions where potatoes are eaten liberally deficiency diseases such as beri-beri and pellagra are practically unknown. Osborne and Mendel (46) found the potato to be as rich in the water soluble
vitamin B as some of the roots, and similar in value to alfalfa, clover and tomato. They also noted no difference in the vitamin B content in peeled or unpeeled potatoes, or in new or old ones.

No work has been published on the separation and determination of the two factors of vitamin B in the potato, hence this study (1) adds to the accumulating knowledge of the multiple nature of vitamin B in foods; and (2) it presents data on the evidence of two vitamin factors of vitamin B in potato.

Experimental

Animals Albino and black and white rats ranging in age from 28 days to 59 days old were used in these experiments. The animals were raised in our own laboratory or obtained from the laboratories of the University of California or Stanford. In each series the rats were as far as possible distributed according to age, sex, weight and parentage.

The rats were kept in individual metal cages with raised screen bottoms to prevent coprophagy. In the first series the rats were weighed daily but later all were weighed weekly. Food recovery was made daily. Distilled water was changed daily if necessary. Once a week the food was weighed back and recorded. The basal diet was fed ad libitum while the vitamin supplement was placed
in glass dishes and fed separately. This supplement which was fed daily was consumed immediately. An accurate record was kept of food intake, changes in diet, weights and conditions of animals.

The following vitamin B free diet was fed to all rats:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purified casein</td>
<td>18.</td>
</tr>
<tr>
<td>McCollum's salt mixture</td>
<td>4.</td>
</tr>
<tr>
<td>Butterfat</td>
<td>8.</td>
</tr>
<tr>
<td>Dextrinized starch</td>
<td>66.</td>
</tr>
<tr>
<td>Agar-Agar</td>
<td>2.</td>
</tr>
<tr>
<td>Cod liver oil</td>
<td>2.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Similar diets used by Sherman (6), Williams and Water- man (32), Chick and Roscoe (33), Kennedy and Palmer (29), and Hogan and Hunter (27) indicate the adequacy of the diet in every respect except that of vitamin B. In a very careful analysis of their basal diet, Kennedy and Palmer (29) found that neither by increasing nor decreasing any one or more of these constituents did they obtain better results, but only when yeast as a source of vitamin B was added.

Purification and Preparation of Constituents of Basal Diet

Casein The purification of casein is of importance in a vitamin B free diet. Evans and Burr (26) and later Kennedy and Palmer (29) found better growth in a diet with commercial casein than with the purified product, intimating the former carried some of the growth promoting factor. In our basal diet the crude casein was
purified by washing in acidulated water (5 cc. glacial acetic acid per 5000 cc. water) for 5½ days, changing the water twice daily. For the last 5 washings distilled water was used. After a thorough rinsing with distilled water the product was dried and ground to a fine powder. Hogan and Hunter (27) and Steenbock (51) use this same method while Kennedy and Palmer (29), Sherman (6) and McCollum (52) have not found this method as satisfactory as extracting with alcohol.

Dextrinised starch To dextrinize the starch, approximately 800 cc. of acidulated distilled water (1% citric acid) was mixed with two pounds of commercial cornstarch (Argo) and autoclaved for one and one half hours at 15 pounds pressure. The mixture was then dried and ground to a fine powder. Kennedy and Palmer (29), Williams and Waterman (32), and Sherman (6) use dextrine in their basal diets while Chick and Roscoe (17) use rice starch, and Hogan and Hunter (27) cornstarch. Richardson (53) dextrinises tapioca for use in her basal diets.

Butterfat Butter was melted at a temperature below 30°C., decanted and filtered through absorbent cotton.

Salt mixture McCollum's salt mixture #185 was used in the basal diet. Evidence has been given that this meets the mineral requirement of the rat when fed in this
proportion in the basal diet. Since these experiments were started, Palmer and Kennedy (42) suggest the addition of 0.5 gram CaCO₃ to the amount of McCollum's salt mixture #185 in the basal diet, but this was not done in our experiments.

Other constituents Agar-agar in shredded form was first used but was changed to the powdered form for convenience in incorporating in the diet. Distilled water was used in all experiments. Cod liver oil was incorporated in the basal diet as a source of vitamin D.

Source of vitamin B factors Nettled compost variety of potato was used throughout this experiment as the source of vitamin B. The potatoes were weighed, pared and weighed again to determine the edible portion. After boiling 600 grams of potato in 750 cc. water for 25 minutes, they were drained, dried and ground to a fine powder. This product was used to determine the amount furnishing a unit of vitamin B complex.

Separation of factors F and G Various methods have been reported in the literature as a means of isolating the F factor. Activated Fuller's earth has been shown to carry F, while the extract carries G (22). Chick and Roscoe (33) obtained a relatively free F factor by Kinnersley and Peters' method of separation (17, 25, 30). Zilva

Squibb's Cod Liver Oil
observed the antiscorbutic factor was not destroyed by exposure to a quartz mercury vapor lamp. Hogan and Hunter (27) confirmed these results when they repeated this experiment and obtained from yeast, a preparation apparently free of the G factor. In this experiment the cooked, dried potato was scattered on a cardboard in a thin layer not over 0.5 cm. thick and exposed for 10 hours at a distance of 25 cm. from the arc of a quartz mercury vapor lamp. This lamp produced 225 ergs of radiant energy per second per cm.² (Accuracy ± 10%). The range in temperature of the material during irradiation was 41°-57° C.

Emmet and Lufce (2) found vitamin F to be stable to heat at 120°C, at 15 pounds pressure for one hour but totally destroyed when heated two to six hours, while the G factor appeared to be stable. Goldberger and his co-workers (12) noted that there was no destruction of the G factor of yeast when heated in the autoclave at 15 pounds pressure for two and one half hours while the F factor was materially affected. Smith and Hendricks (16) autoclaved dried brewer's yeast for six hours at 15 pounds pressure without appreciable loss of the growth promoting factor, while Chich and Roscoe (17) autoclaved for four to

1 Hanovia Chemical Mfg. Co.
2 Gordon Ultra-violet Meter #151.
five hours at 120°C. without loss. To obtain a substance containing G but not F, Sherman and Autmayer (25) autoclaved dry bakers' yeast for 150 minutes at 15 pounds pressure. Autoclaving the potato for four hours at 120°C., after first mixing with distilled water to make a thick paste, did not appear to destroy F. Sherman and Spohn (6) found F to be present in milk after autoclaving in the fluid state for six hours at 100°C. From this evidence we have concluded that autoclaving two hours dry at 15 pounds pressure was sufficient for destroying the F factor. The dried potato was placed in an aluminum pan to a depth of one half inch and autoclaved for two hours at 15 pounds pressure. The autoclaved material was a reddish brown color. This darkening in color in the case of yeast has been reported by Chick and Roscoe (17). Autoclaving did not affect the original weight of cooked, dried potato.

Sherman defines a unit of vitamin B as "that amount which when fed as a daily allowance results in not maintenance of a standard rat over an eight weeks period." Richardson (33) fed 4 grams raw or cooked potato as a unit of vitamin B. This was found to be the equivalent of 0.9 gram cooked, dried potato. Since this proved to be the extreme minimum in dosage, 1.0 gram was used in these experiments as a standard. In some cases this produced some measure of growth. The treatment of potato by auto-
elaving or irradiating made it seem necessary to give this larger dosage as standard by which comparisons could be made.

The animals were divided into eight series with four to nine rats in each group. While the small number of animals used in each series prevents the drawing of definite conclusions, the results obtained at least allow certain predictions to be made.

To prove that our diet was adequate with the exception of a source of vitamin B, one animal was given the basal diet plus yeast as a known source of the two factors of vitamin B. This rat showed a normal growth curve. One animal from each litter was used as a negative control, receiving no supplement with the basal diet. These animals showed a slight initial increase in weight, then maintenance, decline and finally death in from one to four weeks. The younger animals lived longer as a rule, indicating that the impetus for growth in the young was great enough to overcome the effects of a poor diet. (Chart I)

The eight animals in Series II (Chart II) received 1.0 gram of cooked, dried potato as a supplement to the basal diet. Their weight curves show a little more than maintenance, indicating this dosage to contain approximately a unit of vitamin B. #220 receiving a 0.9 gram dosage showed maintenance over a period of eight
weeks. The animals appeared active and normal in most cases, except in size and condition of fur.

In Series III the animals received 1.0 gram of autoclaved potato as a supplement to the basal diet. After an initial gain, the animals declined in weight rapidly, until death occurred. In some cases, the rats prior to death, showed signs of paralysis, reeling gait, arched back and nervousness. The rats survived on this diet from two to four weeks. #210 in Series I was given 1.0 gram autoclaved potato after receiving the untreated supplement for thirteen weeks. Maintenance and slight growth continued for a period of seven weeks when 1.0 gram potato autoclaved for six hours was given the animal. The animal was also put on a one half wire mesh bottom cage to prevent coprophagy. This continued resistance to the autoclaved potato may have been due to a store of the F factor in the body, or to the coprophagistic habits. Quarter inch mesh was satisfactory to prevent coprophagy in the younger animals. #220 in Series I received the autoclaved potato following a period of eight weeks on the untreated supplement. After a slight increase in weight, and then maintenance for a period of seven weeks, paralysis, arched back and reeling gait developed. Weight declined rapidly with death four days later. When #221 showed decline in weight as a result of autoclaved supplement, 0.1 gram of
irradiated potato was added to the diet. Weight did not increase but appearance improved somewhat. This small amount of the F factor prolonged life for three weeks, while #222 without the added irradiated portion died within a day. (Chart III)

Animals in Series IV were given 1.0 gram irradiated potato as a supplement to the basal diet. These animals showed maintenance over a longer period than those receiving the autoclaved supplement but final outcome was the same. There was not the marked loss of weight as in Series III. Symptoms observed were bloody nose, sore eyes and tail, and fissures in the fur. These symptoms have been associated with experimental pellagra by others. (Chick and Roseoe 17, Salmon 22, Goldberger 12) (Chart IV)

To prove the supplementary relationship between the two factors, the animals in Series V received 0.5 gram autoclaved potato and 0.5 gram irradiated potato. These animals showed practically the same weight curves as those on the untreated potato (Series II), but the general appearance did not approach as near normal. Their fur was rougher and somewhat matted. #258 in this series developed paralysis and finally died. #273 was the only animal in all the series which did not consume the total quantity of vitamin supplement. Death evidently resulted from insufficient consumption. (Chart V)
Animals in Series VI received 0.5 gram autoclaved potato and varying amounts of irradiated potato. #235 with 0.5 gram autoclaved potato and 0.1 gram irradiated lived for six weeks before showing symptoms of lack of F in contrast to those in Series III receiving only the autoclaved supplement, which lived from two to four weeks before death occurred. #234 received 0.5 gram autoclaved and 0.2 gram irradiated potato as supplements. At the end of six weeks the animal became wobbly, bluish in color and hair matted and greasy, succumbing at the end of a week. #232 with 0.5 gram autoclaved potato and 0.3 gram irradiated potato showed slight symptoms of paralysis but recovered in a short time. #231 given 0.5 gram autoclaved potato and 0.4 gram irradiated as supplements, developed very pronounced symptoms of paralysis, a bluish color, matted fur, greasy appearance, arched back, reeling gait, and was unusually active and unstable. Death occurred within three weeks. #230 receiving 0.5 gram autoclaved and 0.6 gram irradiated potato showed a slight decline in weight throughout the experiment but developed no symptoms of paralysis. (Chart VI) Keeping one supplement constant in quantity and varying the amounts of the other might give indication as to relative proportions of the F and G factors in potato. However, the small number of animals in this series prevented such a prediction.
To determine whether the animals might show better growth with a greater quantity of one factor than another, or whether the potato was a richer source of either factor, animals in Series VII received 1.0 gram autoclaved potato and 0.5 gram irradiated, or 1.0 gram irradiated and 0.5 gram autoclaved potato. The animals with the larger amount of irradiated potato showed better growth and appearance than those with the larger amount of the autoclaved potato. (Chart VII)

The object of Series VIII was to measure the value of an increased dosage of either factor as compared to the supplementary relationship between the two. The animals were divided into three lots, one lot receiving 1.5 grams autoclaved potato, a second 1.5 grams irradiated, and the third 1.5 grams untreated. This series has not been carried out long enough to allow for definite conclusions. (Chart VIII)

Discussion

From the foregoing observations it is evident that the basal diet lacked vitamin B but was adequate in all other respects, since when yeast, a good source of both factors was added, normal growth occurred. #366, apparently a hardier animal than the others was able to survive over a longer period, even though deprived of vitamin B. Rose in "Foundations of Nutrition" noted
similar results with a young animal on a diet devoid of vitamin A. #286 is being kept in the laboratory on vitamin B free diet.

It appears that 0.9 gram cooked, dried potato contains approximately a unit of vitamin B, as a rat receiving this amount of supplement to the basal diet showed maintenance over a period of eight weeks while rats receiving a 1.0 gram dosage showed slight gain over the same period.

When rats were fed autoclaved potato as the sole source of vitamin B, polyneuritis or experimental beri-beri as described by Salmon (22) and Chick and Roscoe (17) developed. The symptoms characteristic of these diseases, all of which appeared in our animals, were stiffness, reeling gait, arched back, nervousness, unsteadiness, and finally prostration and death. The animals lived from two to four weeks. The two surviving for a longer period of time evidently were capable of storing the F factor from their previous diet, which included untreated potato as a vitamin B supplement.

Animals receiving the 1.0 gram irradiated potato as a vitamin B supplement to the basal diet were maintained over a period of three months or longer without an appreciable increase or decrease in weight, in contrast to the animals receiving autoclaved potato. They appeared
active and had a fair appetite during this time. The fur appeared in better condition than animals on the autoclaved supplement. Chick and Roscoe (17) noticed the following skin symptoms appearing after the fifth or sixth weeks. "(1) Dermatitis and loss of hair from eyelids; which may become stuck together; if the eyelids are loosened by bathing with warm water, the eyes though sunken, appear to be healthy. (2) Front paws stained with blood caused by rubbing the inflamed margins of the nostrils; wetting of the lower portion of the abdomen with blood-stained urine. (3) Dermatitis and loss of fur on the head, around the nose and mouth and on the abdomen. Inflammation of the skin of the ears and a curious and very characteristic oedematous dermatitis of the digits of the paws which become bright red in color. These symptoms became more severe several weeks later. An irregularity in the occurrence of these symptoms was also noted." Salmon (22) observed similar symptoms in working with soy beans and leaves. The only symptoms developed in our rats were bloody nose and tail, sore and sunken eyes. Shortly before death, the animals showed loss of weight, unsteadiness and paralysis. It is possible that the casein in our diet was not pure enough to obtain all the symptoms indicated by these investigators. Palmer and Kennedy (42) found casein carried some G unless purified by alcoholic extrac-
tion. Hogan and Hunter (27) observed the animals deprived of C survived over a longer period than those deprived of F, but the final outcome was the same.

Animals receiving 0.5 gram irradiated and 0.5 gram autoclaved potato as supplements appear to show practically the same weight curves as those receiving 1.0 gram of the cooked, dried potato. As neither autoclaved nor irradiated potato fed alone proved satisfactory as supplements to basal diet, but resulted in death, it is apparent that there is a supplementary relationship between the two factors. There was one death among the rats receiving the mixture of vitamin B factors. This may have been due to individual differences among the animals even though of the same litter. It appears that even a small amount of the F factor with C is capable of prolonging life over a longer period of time than when the C factor is fed alone. Apparently the larger amount of F is capable of preventing the development of paralysis as shown in Series VI. Feeding 0.6 gram irradiated potato as a source of F and 0.5 gram autoclaved potato as a source of C prevented paralysis while less than 0.5 gram of the irradiated portion caused development of polyneuritis at some time.

It appears that a larger amount of the antineuritic factor than the growth promoting, antipellagric
factor is necessary for normal growth and appearance.
The potato may be a richer source of G or perhaps more of
the F factor is required by the rat.

Conclusions
1—The potato is a good source of vitamin B.
2—0.9 gram cooked, dried potato contains approximately
   a unit of vitamin B.
3—Vitamin B is a mixture of at least two distinct factors.
4—Autoclaving potato in the dry state for two hours at
   15 pounds pressure appears to destroy the antineuritic
   factor but not the growth promoting, antipellagraic
   factor.
5—Irradiating under a quartz mercury vapor lamp for ten
   hours at a distance of 25 centimeters gives evidence
   of destruction of the growth promoting, antipellagraic
   factor but not the antineuritic factor.
6—Neither the antineuritic factor nor the growth promot-
   ing, antipellagraic factor fed alone is satisfactory as
   a supplement to a diet lacking in vitamin B.
7—There is a supplementary relationship between the two
   factors, both being required for growth and maintenance.
8—It appears that a larger amount of the antineuritic
   factor than of the growth promoting, antipellagraic
   factor is necessary for normal growth and appearance.
9—Since our animals survived over a longer time, and their
appearance was more normal on supplements of irradiated potato containing vitamin F than on autoclaved potato containing vitamin C, it is possible that the potato is a richer source of C than F, or that the rat requires more of vitamin F than C for normal growth.
1--Mitchell, H. H.
On the identity of the water-soluble, growth-promoting vitamin and the antineuritic vitamin. J. B. C. 40(1919)599

2--Emmett, A. D. and Lurie, G. O.
Water-soluble vitamins. I. Are the antineuritic and the growth-promoting water-soluble vitamins the same? J. B. C. 45(1920)263

3--Funk, C. and Dubin, H. E.

4--Levone, F. A. and Mahlfield, H.
On the identity or non-identity of antineuritic water-soluble B. Vitamin. J. B. C. 57(1923)541

5--Sherman, H. C. and Grose, H. R.
A quantitative study of the destruction of Vitamin B by method for the study of Vitamin B. J. Am. Chem. Soc. 45(1923)2728

6--Sherman, H. C. and Spohn, A.
A critical investigation and an application of the rat growth method for the study of vitamin B. J. Am. Chem. Soc. 45(1923)2719

7--Goldberger, J. and Tanner, W. F.
A study of the pellagra-preventive action of dried beans, casein, dried milk and brewers' yeast, with a consideration of the essential preventive factors involved. U. S. Public Health Reports 40(1925)54

Yeast in the treatment of pellagra and black-tongue. U. S. Public Health Reports 40(1925)927

9--Kinnersley, H. W. and Peters, R. A.
Antineuritic yeast concentrates. I. Biochem. J. 19(1925)820

10--McCollum, E. V., Simmonds, N., and Becker, J. E.
Further Studies on the cause of ophthalmia in
rats produced with diets containing Vitamin A.
J.B.C. 64(1925)161

11---Goldberger, J. and Lillie, R. D.
Experimental pellagra-like condition in the albino rat. U. S. Public Health Reports 41(1926)1025

Butter, fresh beef, and yeast as pellagra preventives, with consideration of the relation of the factor F-1 of pellagra (and black tongue of dogs) to vitamin B. U. S. Public Health Reports 41(1926)297

13---Hauge, S. H., and Carrick, C. V.
A differentiation between the water-soluble growth-promoting and antineuritic substances. J.B.C. 63(1926)403

14---Laird, C. H.
A comparison of the pigeon and the rat as test subjects for Vitamin B. Am. J. Hygiene 6(1926)201

15---Shorman, H. C. and Burton, C. W.
Effect of hydrogen ion concentration upon the rate of destruction of vitamin B upon heating. J.B.C. 70(1926)659

16---Smith, H. L. and Hendrick, E. S.
Nutrition experiments with brewers' yeast. U.S. Public Health Reports 41(1926)201

17---Chick, H. and Roscoe, W. H.
On the composite nature of the water-soluble B vitamin. Biochem. J. 21(1927)608

18---Eddy, E. H.

19---Hassan, A. and Drummond, J. O.
Physiological role of vitamin B. IV. Relation of certain dietary factors in yeast to growth of rats on diets rich in protein. Biochem. J. 21(1927)655
Antineuritic yeast concentrates II. The use of
nonite charcoal in the concentration of torulin.
Biochem. J. 21 (1927) 777

21. McCollum, E. V.
Water-Soluble Vitamins. (Published separately
and also in the volume "Contemporary Develop-
ments in Chemistry." Columbia University
Press, N. Y. 1927)

22. Salmon, W. D.
On the existence of two active factors in the
Vitamin B. complex. J.B.C. 73 (1927) 485

23. Sherman, E. G. and Arntzen, J. H.
A quantitative study of the problem of the
multiple nature of vitamin B. J.B.C. 75 (1927)
307

24. Williams, R. R. and Waterman, R. E.
The composite nature of Vitamin B. Proc. Soc.
Exptl. Biol. Med. 25 (1927) 1 (Eddy, U. H., same,
p. 125) (Daniels and Brook, same, p. 131)

25. Eddy, U. H.
Hunting the vitamin. Am. J. Public Health
16 (1926) 513

26. Evans, H. L. and Burrell, G. C.
A new differentiation between the antineuritic
vitamin B and the purely growth-promoting vita-
min B. J.B.C. 77 (1929) 251

27. Hogan, A. C. and Hunter, J. E.
The plural nature of vitamin B. J.B.C. 73
(1929) 483

28. Hunt, M. H.
The complex nature of vitamin B as found in wheat
and corn. J.B.C. 78 (1929) 85

29. Palmer, L. S. and Kennedy, G.
Fundamental food requirements for the growth of
the rat II. J.B.C. 74, 591; 75, 619 (1927)

30. Salmon, W. D., Guerrettz, P. E., and Hayes, L. H.
On the existence of two active factors in the
vitamin B. complex. II J.B.C. 76 (1929) 467
41--Palmer, L. S. and Kennedy
The Fundamental Food Requirements for the Growth of the Rat. I Growth on a Simple Diet of Purified Nutrients. J.B.C. 76(1927)591
The Fundamental Food Requirements for the Growth of the Rat. II The Effect of Variations in the Proportion and Quality of Recognized Nutrients. J.B.C. 76(1927)610

42--Kennedy, C. and Palmer, L. S.
The Fundamental Food Requirements for the Growth of the Rat. III Yeast and Yeast Fractions as a Supplement to Synthetic Rations. IV Coprophagy as a Factor in the Nutrition of the Rat. J.B.C. 76(1927)591-622

43--Osborne and Mendel
Milk as a Source of Water-Soluble Vitamin J.B.C. 34(1918)557

44--Krueger, H. D., and McCollum, E. V.
Biochemical Investigation of Vitamin B. Physiological Reviews 9(Jan., 1929)120 (Bibliography Complete)

45--Editorial
The Nutrient Habits of Potato Protein J.A.M.A. 51(Aug. 4, 1923)522

46--Osborne, T. B. and Mendel, L. B.
Nutritive Factors in Plant Tissues J.B.C. 41 (1920)451

47--Osborne, T. B. and Mendel, L.
The Vitamin in Green Foods J.B.C. 37(1919)187

48--Drummond, Jack Cecil

49--Kon, Stanislaus Kozimorski
The Nutritional Value of Tuberin, the Globulin of Potato. Biochem. J. 23(1926)261

50--Kon, Stanislaus Kozimorski and Klein, Amielo
The Value of Whole Potato in Human Nutrition Biochem. J. 22(1923)253
31---Underhill, P. P. and Sandol, L. S.
A dietary deficiency canine disease. Further experiments on the diseased condition in dogs described as pellagra-like by Chittenden and Underhill and possibly related to the so-called black tongue. A.J.P. 23(1922)339

32---Williams, R. R. and Waterman, R. E.
The tripartite nature of vitamin B. J.B.C. 76(1925)311

33---Chick and Roscan
The dual nature of water-soluble vitamin B. II

34---Seidel, A.
Further Progress Towards the Isolation of the Antineuritic Factor (Vitamin B) from Brewer's Yeast. J.B.C. 32(1929)658

35---Rogers, A. C., Currant, N. B. and Kempster, H. L.
Concerning the Adequacy of Synthetic Diets for the Growth of the Chick. J.B.C. 64(1925)113

36---Rosendal, J. L.
Studies on the Antineuritic Vitamin B. Preliminary Note on a Possible Second Factor. Biochem. J. 21(1927)1260

37---Osborne, T. B. and Mendel, L. B.

38---Osborne, T. B. and Waksman, Alfred J.
Extraction and Concentration of the water-soluble vitamin B from Brewer's Yeast. J.B.C. 40 (1919)385

CLXVI The Physiological Role of Vitamin B. Part V The Relation of Insulin to Vitamin B Deficiency in Pigeons. Biochem. J. 21(1927) 1828

40---Dutch, E. A.
Observations on the Catabolic Activity of Tissues in Avian Polyneuritis. J.B.C. 36(1918)68
51—Steenbock, Harry
Personal Communication

52—McCollum, F. V.
Personal Communication

53—Richardson, Joogie
Personal Communication

54—Zilva, S. S.
Conditions of Inactivation of Accessory Food Factors. Biochem. J. 10(1922)42
#260 Receiving 1.0 Gram Cooked, Dried Potato
#261 Receiving 1.0 Gram Autoclaved Potato
#263 Receiving 0.5 Gram Autoclaved and 0.5 Gram Irradiated Potato