

## Vitamin B, Relative Nutritive Value and Palatability of Germinated Corn (*Zea mays* L.)<sup>1</sup>

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### RINGKASAN

Perbezaan mengenai kandungan riboflavin, niacin, thiamin dan Relative Nutritive Value (RNV) didalam jagong kecambah adalah dikaji. Biji-biji jagong dicambah selama empat hari pada suhu 30°C, kemudian dikeringkan pada suhu 50°C dan dikisar. Vitamin-vitamin diatas dianalisa dengan menggunakan kaedah mikrobiologi RNV dianalisa dengan menggunakan *Tetrahymena pyriformis* W ATCC 10542. Ujian rasa dibuat keatas kepingan jagong goreng yang dibuat dari jagong kecambah. Kepingan jagong goreng juga dianalisa mengenai kandungan ketiga-tiga vitamin dan Relative Nutritive Value.

### SUMMARY

Changes in the riboflavin, niacin, thiamin and Relative Nutritive Value (RNV) in germinated corn were studied. The corn were germinated for four days at 30°C and then dried at 50°C and ground. The vitamins were analysed by microbiological methods. The RNV was analysed by using *Tetrahymena pyriformis* W ATCC 10542. Acceptability was evaluated on corn chips made from germinated corn. The three vitamins and the Relative Nutritive Value of the corn chips were also analysed.

### INTRODUCTION

Corn is a staple of many countries in the world. The nutritive value of corn is not complete since it lacks certain essential amino acids and also must be supplemented with certain minerals and vitamins. Because of the importance of corn as a food source, better use of corn for home preparation should be made so as to provide the nutritive value which is comparable to that of animal protein. One method is by mixing plant proteins such that the resulting combination will give a good balance and recommended levels of amino acid.

Another method is by germination which is one of the simplest ways of improving the nutritional quality of seeds. Seeds generally will increase in available nutrients during germination (Everson *et al.*, 1944; Desikachar and De, 1950; Chen, 1970; Chew *et al.*, 1975). Germination of corn seeds does not require sunlight or soil. The time of sprouting is short and the sprout yield is high.

In this study, the vitamin content (riboflavin, niacin, thiamin) and RNV (Relative Nutritive Value) of corn was determined. The possible use of this germinated seed for consumption was determined on their acceptability by sensory evaluation.

### MATERIALS AND METHODS

#### *Sprouting of seeds*

The shelled corn was obtained from a local food store in Columbia, Missouri. The seeds were washed several times and soaked in tap water, which was four - five times the volume of the seeds, at room temperature for 16-18 hr. The seeds were germinated in a wooden tray with a screened bottom measuring 49 cm × 63cm and lined with wet paper towels. Two layers of wet paper towels covered the seeds to prevent rapid moisture loss. They were germinated in an incubator set at 30°C for four days. The seeds were washed three times per day; mouldy seeds were discarded. After four days, the sprouts were washed and dried at 50°C. They were ground through 1 mm mesh screens in a Thomas Wiley Laboratory mill.

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### Determination of Moisture and Nitrogen

The moisture content of the samples was determined by the air-oven method of the AOAC (1975). The micro-kjedahl method of the AOAC (1975) was used to determine the nitrogen content of a fat-free sample of the ground seeds. To remove the fat, the sample was extracted three times with diethyl ether and once with 95% ethanol. It was finally washed with ether to remove the residual alcohol and air-dried at room temperature.

### Determination of Relative Nutritive Value

The Relative Nutritive Value (RNV) of the corn meal was determined using *Tetrahymena pyriformis* W (ATCC 10542) according to the procedure of Stott and Smith (1963). Certified casein was used as a reference protein. The fat-free sample containing 12 mg. nitrogen was weighed into a 100 ml beaker. A suspension of the sample in distilled water was made to give a nitrogen content of 3 mg/4 ml, and the pH was adjusted to 8.2.

Four ml of the sample suspension were pipetted into screw-capped culture tubes (20 × 150 mm). Each suspension was prepared in triplicate. Working solutions of minerals, nucleic acids, glucose and vitamins were added in the sequence described by Stott and Smith (1963). *Tetrahymena* medium, prepared according to the formula of ATCC, was used for maintaining the culture and preparation of inoculum. Each culture tube, after being autoclaved for ten minutes at 15 lb. pressure was cooled and then inoculated aseptically with three drops of a three day-broth culture of the organism. After inoculation the tubes were incubated in an inclined position (about 15°) at room temperature for four days.

After incubation, the culture tubes were shaken on a vibrator for a few seconds and 1 ml. of the culture was transferred to a 20 × 150 mm screw capped culture tube containing 1 ml of 36% formaldehyde preserving fluid. *Tetrahymena* cells were counted in a double lumicyte hemacytometer (Propper Manufacture Co, Inc. Long Island City, N.Y.).

Cells in eight alternate mm squares were counted, and the mean number per square mm was used to calculate the population of the test culture in units of 10<sup>4</sup> organism/ml. The inoculum count was in units of 10<sup>2</sup> organism/ml. The RNV in percentage was calculated according to the formula derived by Helms and Rølle (1970).

$$\text{RNV} = \frac{\log (\text{count for test protein}) - \log (\text{count for inoculum})}{\log (\text{count for casein}) - \log (\text{count for inoculum})} \times 100$$

### Determination of Riboflavin, Niacin and Thiamin

The microbiological assay method of Difco (1977) was used to determine these vitamins. For the determination of riboflavin and niacin, preparation of samples for assay was done according to The Association of Vitamin Chemists (1966). Preparation of samples for assay to determine thiamin content was done according to the procedure of Sarett and Cheldelin (1944). The test organisms used to determine riboflavin, niacin and thiamin are *Lactobacillus casei* ATCC 7469, *Lactobacillus plantarum* ATCC 8014 and *Lactobacillus fermenti* ATCC 9338 respectively.

### Preparation of Corn Chips

A recipe for corn chips was developed in the laboratory. Ingredients: 125 g control corn; 1.8 g barbeque seasoning; 3.5 g monosodium glutamate; 4 g minced onion; and 30 ml water.

The corn chips fabricated from the germinated corn meal were made with 88 g (¾ C) of the corn meal produced from germinated corn and 31 g (¼ C) nongerminated (control) corn meal. The ingredients were mixed and kneaded into a dough and kept overnight in the refrigerator to improve the flavour. The dough was rolled thinly cut in short strips and deep fried for 1 min 15 sec. at 175°C to obtain desired colour and crispness.

The chips were ground into a meal and analysed for the moisture and nitrogen percentages, RNV and vitamins.

### Sensory Evaluation

Sensory evaluation was conducted by seven trained panelists. The corn chips were judged on seven attributes; brittleness, graininess, corn flavour, spicy flavour, sweet taste, bitter taste and earthy flavour. These attributes were scored on a 1-5 range. The testing was done under dim white light due to the variation in colour of the two treatments of the chips.

Sensory evaluation of the consumer panel on the corn chips was done on a seven point hedonic scale ranging from "like very much" to "dislike very much". The data were analyzed by t-test (Amerine *et al.*, 1965).

## RESULTS AND DISCUSSION

For the purpose of discussion the corn meal made from non-germinated corn will be considered as control.

*Moisture and Nitrogen Content*

The results are shown in Table 1. There was slightly less moisture in corn chips made from the control and the germinated corn meal as compared to the percentage of moisture of the original samples. The data indicated there was a higher concentration of nitrogen in the germinated corn than in the control. It was also found that the corn chips made from germinated corn had a higher percentage of nitrogen than the corn chips made from the control. According to Folkes and Yemm (1958) several amino acids and other nitrogen compounds consistently showed increase in basic N during germination represented by the synthesis of nucleotides and nucleic acids. Wang (1977) also reported an increase in percentage of nitrogen in germinated corn. The increase in percentage of N indicated an increase in crude protein in the germinated corn.

TABLE 1

Means of Moisture and Nitrogen Content of Corn Meal

Treatment	Moisture %	Nitrogen %
Control corn meal	8.13	1.52
Germinated corn meal	8.01	1.63
Control corn chips	5.47	1.51
Germinated corn chips	7.69	1.70

*Riboflavin, Niacin and Thiamin in Germinated Corn*

The results are shown in Table 2. The levels of each of the three vitamins are expressed in mg/100 g. Riboflavin increased significantly ( $P < 0.01$ ) from 0.10 mg/100 g in the control to 0.27 g in corn meal made from germinated corn.

TABLE 2

Means<sup>1</sup> on a Dry-Weight Basis for Nutritive Values of Corn Meal made from Nongerminated and Germinated Corn.

Treatment	Riboflavin mg/100 g	Niacin mg/100 g	Thiamin mg/100 g	RNV <sup>2</sup> %
Non germinated (control)	0.10 a	2.19 a	0.31 a	68.8 a
Germinated	0.27 b	3.18 b	0.33 b	86.0 b

<sup>1</sup> Means followed by the same letter are not significantly different ( $P < 0.01$  for riboflavin and RNV,  $P < 0.05$  for niacin)

<sup>2</sup> Relative Nutritive value

Burkholder (1943) germinated the corn seeds for five to six days and found the riboflavin increased four times in germinated corn. Removal of the radicle after the first day of germination prevents further riboflavin formation by the remaining part of the seeds (Goodwin, 1963). The data showed a significant ( $P < 0.05$ ) increase of niacin from 2.19 mg/100 g in control to 3.18 mg/100 g in corn meal made from germinated corn. Burkholder (1943) reported that nicotinic acid was synthesized during germination of *Retention of vitamins after processing as corn chips* maize. It was suggested that quinolinic acid which formed during plant metabolism was a precursor of nicotinic acid (niacin). Hadwiger *et al* (1963) obtained evidence of the conversion of quinolinic acid to niacin in yellow dent corn.

In the case of thiamin there was 0.31 mg/100 g in the control corn meal and 0.33 mg/100 g in corn meal made from germinated corn. According to Burkholder and McWeigh (1945) light is necessary for the synthesis of thiamin in germinating seeds. The corn for this study was germinated in an incubator and light was not provided.

*RNV (Relative Nutritive Value)*

The RNV of the corn meal made from germinated corn was significantly ( $P < 0.01$ ) higher than the control. The higher RNV in corn meal made from germinated corn was due to the increase in essential amino acids (Wang, 1977). In corn chips there was a decrease in value of the RNV in both the chips made from the control and the germinated corn.

Although there was a significant ( $P < 0.01$ ) difference due to treatment in riboflavin, niacin and RNV, the data in Table 2 illustrate that there was very little loss of riboflavin in the processing of corn chips for either treatment, control or germinated. There was significantly ( $P < 0.01$ ) higher riboflavin content in chips made from the control (Table 3).

TABLE 3

Means<sup>1</sup> on a Dry-Weight Basis for Nutritive Value of Corn Chips from Nongerminated and germinated corn.

Treatment	Riboflavin mg/100 g	Niacin mg/100 g	Thiamin mg/100 g	RNV <sup>2</sup> %
Nongerminated	0.09 a	1.97 a	0.17 a	61.5 a
Germinated	0.21 b	3.21 b	0.20 a	73.0 b

<sup>1</sup> Means followed by the same letter are not significantly different ( $P < 0.01$ )<sup>2</sup> Relative Nutritive Value

TABLE 4

Means<sup>1</sup> for Quality Attributes as Determined by Laboratory Panels

	Panel Score		Attributes				
	Texture		Flavor				
	Brittle	Grainy	Corn	Spicy	Sweet	Bitter	Earthy
Nongerminated (Control)	4.6 a	3.9 a	3.8 a	3.6 a	2.0 a	2.0 a	2.6 a
Germinated	3.4 b	3.8 a	2.5 b	3.2 a	2.6 b	4.2 b	4.0 b

<sup>1</sup> Means followed by the same letter are not significantly different ( $P < 0.05$ )

There was a slight decrease of niacin in corn chips made from the control, whereas the value of niacin was not affected in corn chips made from germinated corn (Table 2).

There was a loss in thiamin in both the control (from 0.31 mg/100 g to 0.17 mg/100 g) and in the corn chips made from germinated corn (from 0.33 mg/100 g to 0.20 mg/100 g) (Tables 2 and 3). As thiamin is heat sensitive, the reduction in the levels of the vitamin can be attributed to the cooking process.

#### Organoleptic testing

Mean scores for all seven attributes evaluated by sensory tests are listed in Table 4. Only the graininess and the spiciness factors were not statistically significant. The differences in means were much greater in the bitterness (2.0 and 4.2) and earthiness (2.6 and 4.0) attributes of the products. If the germinated corn sprouts were cooked in a soup, there might be a greater acceptance of the flavour. The bitterness factor might not be apparent in the fresh sprouts. Removal of the radicle as in cooking of soybean sprouts may improve the flavour of the corn chips made from germinated corn.

#### CONCLUSION

There is a significant increase of niacin ( $P < 0.05$ ) and riboflavin ( $P < 0.01$ ) in germinated corn compared to that of the control corn

meal. There is no change in the thiamin content. The percentage of RNV of the meal from germinated corn was significantly ( $P < 0.05$ ) higher than that of the control corn meal. There was a slight decrease in riboflavin, niacin, percentage of RNV and there was a marked decrease in thiamin in corn chips made from germinated corn. In the sensory evaluation of corn chips made from germinated corn, only two attributes, namely, spiciness and graininess, were not significantly different when compared to the control corn meal. The difference between means ( $P < 0.05$ ) was much greater with the bitterness and the earthiness attributes.

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