VITAMIN B-6 CONTENT OF SELECTED FOODS AFTER INSTITUTIONAL COOKING AND HOLDING PROCEDURES

by

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(ABSTRACT)

The vitamin B-6 content of three foods, roast top round of beef in au jus, canned green beans in pot liquor, and whole baked potatoes was measured. These foods are typically served together as choices on the six week cycle menu at three dining halls on the University campus. Random samples were taken when the foods were raw, just cooked, and held for one, two, and three hours. Two additional samples of roast beef were selected as the beef received more cooking and holding treatments. Saccharomyces uvarum was the test organism used in the A.O.A.C. microbiological analyses for vitamin B-6 quantitation. Total vitamin B-6 was measured, not the individual vitamers. Roast beef lost total vitamin B-6, sometimes in significant quantities at every sample time. Green beans followed the same pattern of loss with cooking and increased holding times. Some of the vitamin was leached into the au jus and pot liquor as they were held with the beef and beans, respectively. Whole baked potatoes also lost in vitamin B-6 content with each sample time; however, this loss was not always significant. Institutional cooking and holding procedures utilized for these selected foods had adverse effects on their vitamin B-6 content.

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INTRODUCTION

More people now than ever before are eating their meals away from home. Institutional feeding accounts for over one-third of the foodservice units in operation in the United States today. Annual sales from these foodservice units have risen from $42.7 billion in 1970 to $114 billion in 1980. Institutional feeding accounts for $19.7 billion yearly. Included in institutional feeding accounts are college and university foodservice units (1).

The Recommended Dietary Allowance for vitamin B-6 for college aged students, generally 18-22 years is 2.2 mg daily for males and 2.0 mg daily for females (2). The requirement of vitamin B-6 as a cofactor in numerous enzyme systems is well known (3). Walker and Page analyzed composite meals in 50 colleges; 84% of these meals contained less than 2.0 mg per day of vitamin B-6 (4).

As the amount of food increases, so does the time needed to cook it. The size of the batch of the food cooked at one time does affect nutrient losses (5). This is especially true for water-soluble vitamins. Several authors have examined the effect of home or laboratory cooking procedures on nutrient content (6-8). Prusa et al. (9) examined nutrient losses in satellite and central kitchen preparation; Dong et al. (10) analyzed foods as served from a military installation serving line. These data are considerably lower than published reports as most publications list nutrient values for foods in the raw state (11).

Nutrient content data for foods prepared in institutional kitchens are rather sparse according to Stewart (12). Changes in the foodservice distribution system have occurred over the past two decades. Specifically, pre-cooking, convenience foods, and a proliferation of new foods, as well as cost factors and analytical difficulties with measuring some of the nutrients could account for this lack (12). This project was designed to provide data on the effects of institutional cooking and holding procedures utilized in a large foodservice.

The objectives of this study were to determine the vitamin B-6 content of three selected foods, which are typically served together as dinner meal choices, at the Virginia Polytechnic Institute and State University's foodservice. The foods, roast beef in au jus, green beans in pot liquor, and baked potatoes, were sampled when the foods were raw, just cooked, and after holding for one, two, and three hours. Also determined was the percentage of vitamin B-6 retained in the foods at each sampling time. Cooking procedures at each dining hall were not controlled, as foods were selected as a typical student could have been served these foods.

REVIEW OF LITERATURE

Engler and Bowers (7) indicated that there are trends in the foodservice industry to maximize use of the facility and shorten labor hours in an effort to keep down rising expenditures. Livingston et al. (5) discussed foodservice handling techniques, among which are storage times and temperatures, container and package sizes, thawing methods, batch sizes, cooking methods, time held hot, temperature of cooking and holding, oxygen exposure, light and freezing methods. Although the above procedures can cause losses of many of the B vitamins, all have the potential to cause losses of vitamin B-6. Vitamin B-6 exists in three separate forms. Pyridoxine (PN) appears to be more stable in foods while pyridoxal (PL) and pyridoxamine (PM) are much less stable. PN is the major vitamer form in potatoes, while beef contains mainly PM and green beans contain PL (13). Vitamin B-6 is believed to be relatively stable in the presence of acid, alkali, and dry heat (not moist heat); it is, however, destroyed by oxidation and light. Engler and Bowers (7) stated that the loss of vitamin B-6 in reheated turkey breasts is believed to be due to their exposure to heat, light, and oxidation; refrigerator storage was not believed to be a contributing factor. Schroeder (14) compared raw, frozen, and canned foods as to their vitamin and trace mineral content. He reported losses of 36.7 to 44.6% in frozen and losses of 57.1 to 77.4% in canned vegetables as compared to raw.

The current researcher has found only two articles approximating actual foodservice procedures (9,10); thus, this research could add to

the body of current literature. In order to sample foods as served, Dong et al. (10) utilized a military foodservice operation; as served referred to foods sampled by selecting them directly from a military cafeteria serving line; 174 meal items were sampled. Nutrient values for raw foods are far higher than for cooked samples as this article illustrated.

Meyer et al. (8) determined vitamin B-6 content of paired beef muscles, both raw and after cooking. Vitamin B-6 retention percentages were also reported with ranges from 45 to 52%. It was noted, however, that some of the vitamin B-6 was recovered in the drip (8). It must be noted, however, that this article reported practices far different than those practiced in a large foodservice. That is, there were smaller quantities used and more careful individual attention given than in a large foodservice.

Ang (15) determined the feasibility of freezing samples for subsequent analysis by storing 200 gm samples of frozen ground broiler meat for up to 12 months. These raw frozen samples retained 91 to 95% of their initial unfrozen total vitamin B-6 content.

In an earlier study, Ang (6) examined differences between strains, sex, and geographical production region of broilers. Sex made no difference but strain and region showed significant differences in vitamin B-6 content. It was also noted that nutrient intake, climate, management, and biological variations could have an effect on the vitamin B-6 content of chickens.

Bowers et al. (16) pointed out that less vitamin B-6 was lost in the cooking of pork muscle when the sample was cooked in a conventional

oven rather than a microwave. However, this difference was not statistically significant.

The vitamin B-6 content of canned green beans used in school lunches was determined by Prusa et al. (9). The vitamin B-6 concentrations of both baking potatoes and green beans were analyzed by Polansky (17); similar vitamin B-6 values for both foods were obtained with chromatographic methods as well as nonchromatographic. Green beans contained a higher percentage of PL, while PN was the major form of the vitamin in potatoes. All values reported in the Polansky (17) study were for fresh, raw vegetables. The vitamin B-6 content of potatoes and green beans varied with varietal, growing, and handling conditions. Polansky also noted that there was no need to chromatograph samples into the PL, PN, and PM vitamers (17). In agreement with this statement, Polansky and Toepfer in a later article (18) sampled beef and analyzed it for vitamin B-6 content and observed similar results regarding chromatography and also found PM to be the predominant vitamer in beef.

According to Augustin (22), potatoes rank number one of all vegetable crops consumed in the United States. Augustin et al. (19) agreed with Page and Hanning (20) in that the vitamin B-6 content did increase after storage of 2 to 6 months.

Augustin et al. (21) separated tuber peel from flesh, and with oven baking, there was a substantial gain in vitamin B-6 in the peel. Problems encountered in this approach were morphological differences in peel and flesh, decreases in moisture content of peel during cooking, and amounts of flesh adhering to the peel (21).

Page and Hanning (20) examined the vitamin B-6 content of baking potatoes both raw and after cooking. Variances in vitamin B-6 content could be attributed to bound vitamin B-6, storage conditions and temperatures, varying soil compositions, and fertilizer conditions. In a 1975 article, Augustin (22) discussed the subject of variations in nutritional composition of raw varieties of tubers. The reported variation in all nutrients tested was incredibly large. Differences in location in the same field can contribute to differences in the vitamin content.

Augustin et al. (21) examined changes in the vitamin concentration of potatoes during freezing and cooking. Percent retention in cooked potatoes ranged from 78 to 113%, showing the great variability in vitamin B-6 retention in potatoes. In a 1980 article, Augustin (23) reported that the retention of the vitamin in baked, chilled, and reheated potatoes ranged from 88 to 109%. Chilling increased the vitamin B-6 content, possibly due to increased moisture.

Composite samples of meals served to college students were collected from fifty colleges and universities. These were analyzed for vitamins and proximate composition by Walker and Page (4). The vitamin B-6 content was below 2.0 mg per day in 84% of the analyzed meals. Meals served in more than one-fourth of these colleges and universities contained less than 1.0 mg B-6 per day (4). Shizukuishi et al. (24) examined the prevalence of vitamin B-6 deficiency in 174 university students; 30% of the subjects were deficient in the vitamin while 93% were reported to have marginal to deficient status. Driskell et al. (25) reported that many of the 155 college age students

evaluated were deficient in vitamin B-6 nutriture; 30.3% of the males, 16.4% of the females, and 41.4% of the females using oral contraceptives had suboptimal vitamin B-6 status. Inadequate intakes of vitamin B-6 as well as magnesium, zinc, and folate may be more prevalent than those of other nutrients typically included in nutrition surveys according to Hegsted (26).

In summary, vitamin B-6 may be lost due to cooking procedures. Vitamin B-6 values vary between types of cooking procedures used and whether the food is raw, cooked, or held. Finally, the prevalence of vitamin B-6 inadequacy especially in young adults, has been documented. Hopefully this research will add to the knowledge of the effects of institutional cooking and holding practices on the vitamin B-6 content of foods.

METHODS AND MATERIALS

Justification of food choices

Three of the dining halls at the Virginia Polytechnic Institute and State University campus were chosen for use in this study. Dining halls A, B, and C respectively serve approximately 1800, 2400, and 3400 students at each meal. These figures are approximately representative of other college and university foodservices. The three selected foods, roast top round of beef in au jus, canned green beans in pot liquor, and whole baked potatoes were chosen because they are representative dinner choices on the university campus. That is, they appear together as dinner choices on the six week cycle menu and separately at least once a week. These foods are popular choices with the students; also their recipes have no major added ingredients (27).

Explanation of sample times

A diagram of sampling times for selected foods is given in Figure 1. For green beans, pot liquor, and potatoes, the five sample times were represented as follows: raw, that is before the addition of heat to the food in the dining hall; as cooked, that is the point when the cook turned off the heat and placed the food in pans to go to the serving line; and one hour, two hours, and three hours held; which corresponded to foods held in hot holding units for one, two, and three hours with the heat set at approximately 66°C. The collection times utilized for au jus differed only slightly in definition of sample times. Raw was referred to as when the au jus was boiling but before it was poured over the roast beef; as cooked, referred to the sample

raw - ready to cook

first cooking * - initial cooking

held before reheating * - held overnight at ∿4°C

as cooked - ready for serving line

1 hr held - 1 hr ∿66°C

2 hr held - 2 hr ∿66°C

3 hr held - 3 hr ∿66°C

FIG. 1. Sampling times for selected foods.

*Sampling times for roast beef only.

taken right after (within five minutes) boiling au jus was poured over the roast beef; the holding times were as with green beans and potatoes.

The sampling times for the roast beef were as follows: raw, first cooking, held before reheating, reheated to serve, and one hour, two hours, and three hours held. Beef that had not yet been roasted was referred to as raw. The first cooking sample was taken within one hour of the beef being removed from the ovens; for dining hall A, this was the initial measurement. Held before reheating was the sample taken just before the beef was sliced and reheated with au jus for serving. As cooked corresponded to reheated to serve. The held samples were the same as for the other selected foods.

Collection of food samples

Each of the selected foods was collected on three separate occasions from each of the three dining halls. Roast beef and au jus were collected between March 29 and May 31, 1983; green beans and pot liquor between February 19 and April 14, 1983; and potatoes between February 24 and April 7, 1983.

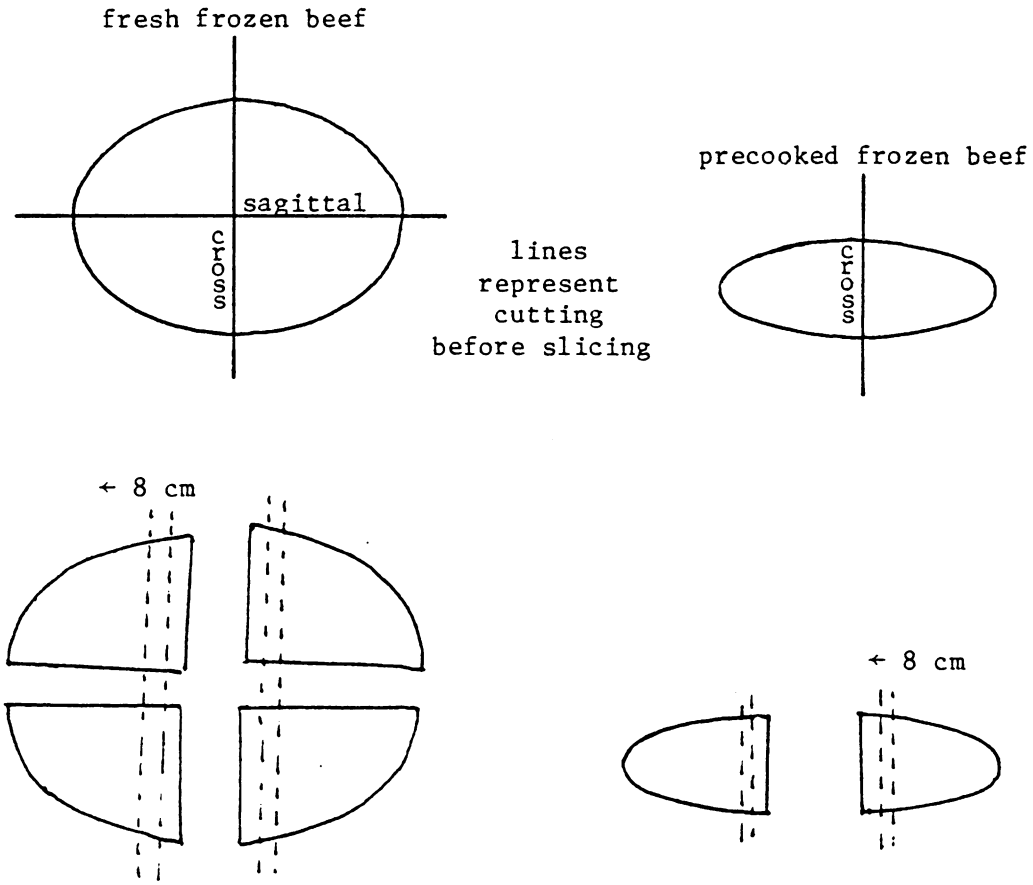
The roast beef utilized at dining hall A was precooked and frozen; it was obtained from Swift Independent Packing Company, Roanoke, VA. Nutrient composition data were not available from the company on this product. The roast beef was thawed and a first cooking sample was taken. The roast beef was selected from a random number of rounds. As the dining hall employees sliced these rounds, slices were separated and randomly placed into pans which were labeled for the held before

reheating, as reheated, and for one, two, and three hours held samples.

Figure 2 describes the sample selection for roast beef. A sample of roast beef consisted of eight randomly selected servings of approximately 100 gm. Each sample was placed in a doubled plastic bag, covered with aluminum foil to protect from light, and placed in crushed ice in a cooler until homogenization later in the day. In dining halls B and C, where fresh frozen beef was used, a raw sample was taken as soon as the beef was thawed enough to cut. Another sample was taken as soon after the beef was roasted and cooled enough to slice, usually within one hour. This sample was designated as first cooking. The labeled pans were used for collecting samples during the subsequent sampling times. The remaining samples were selected in essentially the same manner in all dining halls.

The roast beef was homogenized in a Waring blender with a known amount of distilled deionized water and several drops of Antifoam A Emulsion (Sigma Chemical Company, St. Louis, MO, A 5758), to achieve a homogeneous slurry. Duplicate samples were placed in heavy plastic bags, sealed, placed in paper cartons, and frozen in two separate freezers at approximately -10°C until analyses.

Au jus was sampled one time prior to the addition to the roast beef and at every time with the roast beef from as cooked through three hours held. The boiling au jus was used to heat the cold roast beef. Approximately 45 ml of au jus were put into two screw top test tubes placed in two large paper cartons, and frozen in duplicate freezers at -10°C until analyses.



dotted lines represent area where 3 ∿100 gm slices were cut

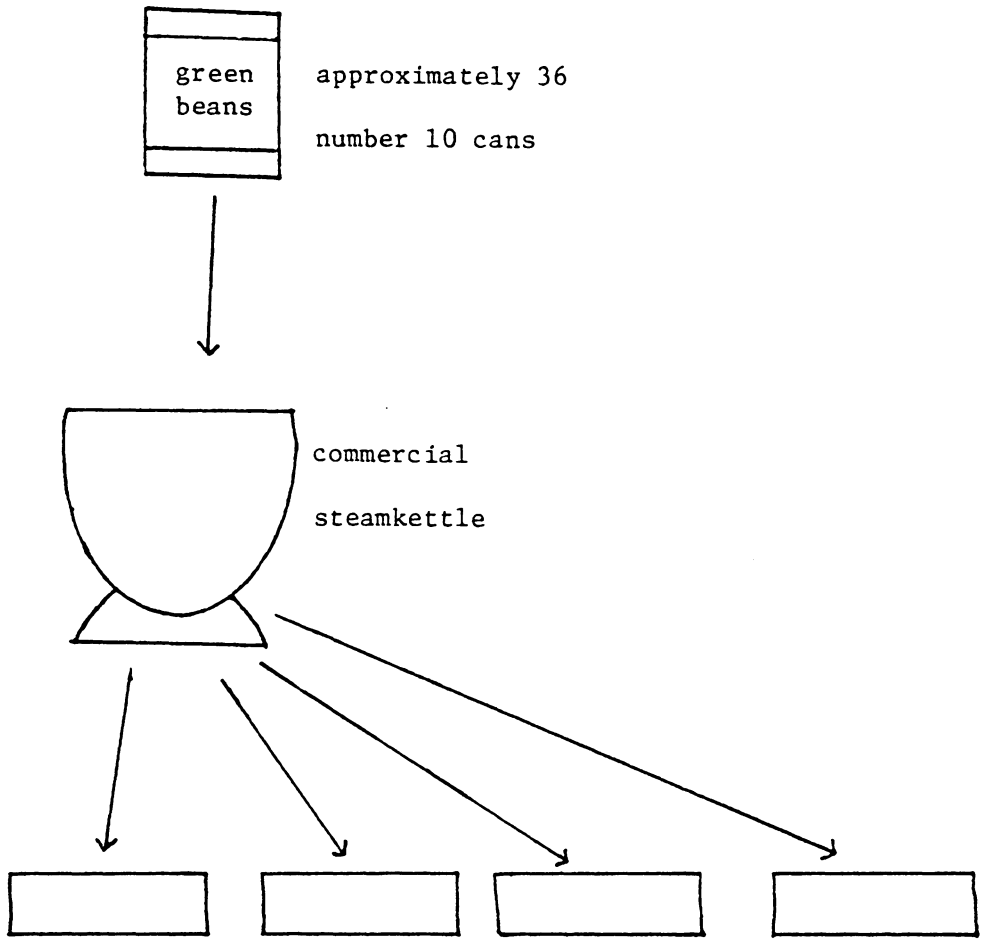
Twenty slice aliquots from random rounds were arranged in 5 serving line pans.

FIG. 2. Sample selection for roast beef.

Samples of the ingredients from which the au jus was prepared were obtained. These included beef soup base, Gravy Master (Major Products, Little Ferry, NJ), and beef scraps and drippings; samples were taken from opened containers in the dining halls. Samples were placed in screw top test tubes, placed in paper cartons, and frozen at approximately -10°C until analyses.

The green beans sampled were Hillco brand (William R. Hill & Company, Inc., Richmond, VA) canned green beans from lot numbers 3246L, 7202U, and 1CGB5. The dining halls each used between 24 and 48 number 10 cans on the days selected for sample collection. At least 24 cans were emptied into a large steam kettle and the raw sample was taken after stirring to obtain a homogeneous mixture (Figure 3). A sample consisted of 12 serving line slotted spoons full of green beans. The raw sample was selected directly from contents of the unheated steam kettle. After boiling the green beans were placed into four labeled serving line pans for subsequent sampling times. Samples were placed into sealed plastic bags inside covered paper cartons and held in crushed ice until homogenization. Later in the day, the green bean samples were homogenized with a known amount of distilled deionized water in a Waring blender to form a slurry. Duplicate samples were placed into plastic bags in two paper cartons and frozen in duplicate freezers at approximately -10°C until analyses.

Along with the green beans, pot liquor (the liquid in which the beans were held) was collected. Aliquots (45 ml) were placed into two screw top test tubes which were placed in two paper cartons and frozen



After heating the aliquots were placed in serving line pans in hot holding units.

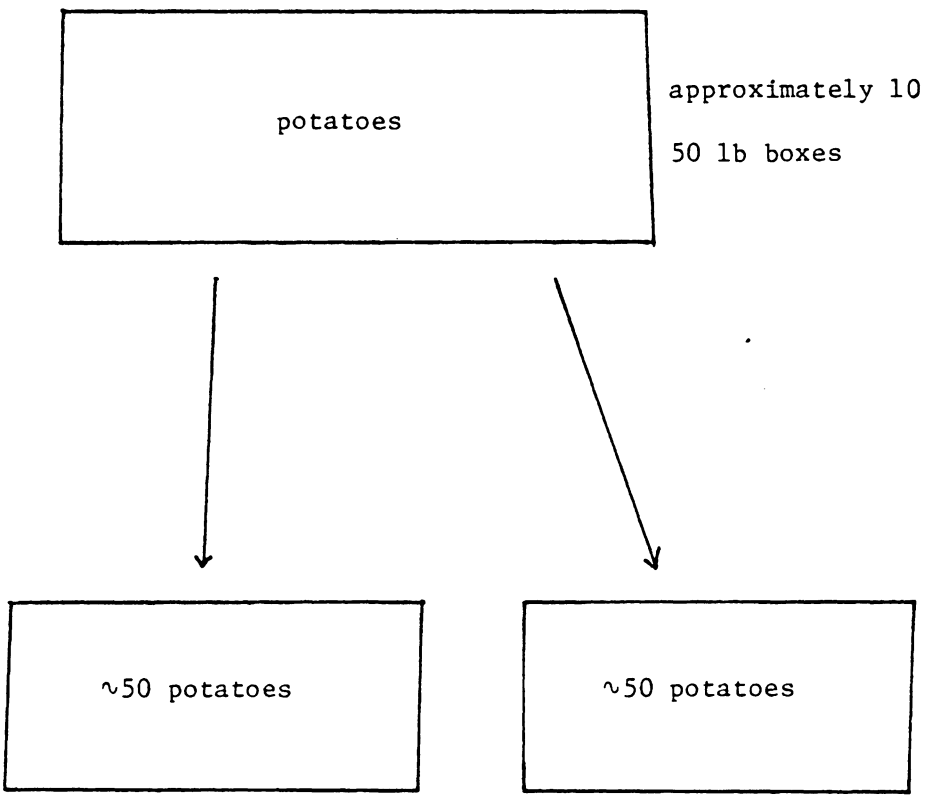
FIG. 3. Sample selection for green beans.

in different freezers at approximately -10°C until analyses.

The potatoes sampled came from several companies located in Washington, Idaho, and Wisconsin; they arrived packed in 50 lb boxes. The dining halls used between seven and 16 boxes on any given day. Between 10 and 12 raw potatoes were sampled from each box and placed in two large serving pans (Figure 4). A sample consisted of eight randomly selected potatoes. Raw samples were randomly selected four from each pan. Potatoes were held overnight in cold water (about 4°C) after being cleaned but before cooking.

Dining halls A and C baked the potatoes in conventional ovens; dining hall B used a commercial steamer to cook potatoes. The as cooked and one hour held samples were selected from the pan labeled number one. The two hour and three hour held samples were selected from the other pan. Potato samples were wrapped in aluminum foil, placed in double plastic bags, and held in crushed ice in a cooler. In order to separate peel and flesh, the skin was cut off leaving the peel about one cm thick. Flesh and peel were homogenized separately with distilled deionized water using a three speed Waring blender. Several drops of Antifoam A emulsion were added to the raw potato/water mixture during homogenization, in order to achieve a consistent texture. Duplicate samples of the slurries were placed into heavy plastic bags inside paper cartons, covered, and frozen in duplicate freezers at -10°C until analyses.

The present researcher collected the first sample of each of the three foods from each of the three dining halls. There were four other



Potatoes were separated into two separate baking pans, and cooked and held in a hot holding unit.

FIG. 4. Sample selection for potatoes.

people collecting samples; all were trained by the present researcher using a standard set of collection directions (Appendix 1).

Microbiological assay for vitamin B-6 content

A modification of the A.O.A.C. (Association of Official Analytical Chemists) procedure for the determination of vitamin B-6 in foods was employed (28-31). Reagents used in these procedures are listed in Appendix 2. Chemicals and vendors are listed in Appendix 3.

A. Assay inoculum

Saccharomyces uvarum (ATCC 9080, formerly known as S. carlsbergenesis) was incubated fresh weekly on Difco bacto YM agar slants overnight in a shaking waterbath set at 30°C. Ten ml of pyridoxine Y media for inoculum were transferred to each of two screw top centrifuge tubes and steamed for 10 minutes. S. uvarum cells were aseptically transferred from the slant to the cooled media. These cells were then incubated at 30°C in a shaking waterbath for 18 to 20 hours. Then cells were centrifuged, the supernatent decanted aseptically, and the precipitant washed three times with approximately 10 ml sterile saline. The final suspension was used as the assay inoculum.

B. Sample preparation

The frozen sample slurries were defrosted under refrigeration overnight. Approximately 5 gm (range 1-10 gm) of each sample slurry were weighed. To this aliquot, 170 ml 0.055 N HCl were added and the mixture autoclaved for five hours at 121°C and 15 psi. Samples were cooled, adjusted to pH 4.5 with 6 N KOH, and glacial acetic acid, brought to 250 ml, and filtered through two sheets of Whatman #42 filter

paper. This was designated as the extracted sample.

C. Sample assay

All analyses of standards and sample extracts were run in triplicate. Sample extracts, 0.1 to 1 ml, as well as working standards (0, 0.5, 1, 2, and 4 mg PN HCl) were pipetted into test tubes. Pyridoxine Y media for sample assay, 5 ml, was added and the volume brought to 10 ml with distilled deionized water. The contents of the tubes were then steamed for 10 minutes, cooled, and aseptically inoculated with one drop of the previously mentioned assay inoculum. The contents of the tubes were then incubated at 30°C in a shaking water bath for 20 hours.

At the end of the incubation period, the contents of the tubes were steamed for five minutes in order to stop the growth of the test organisms; the contents were then allowed to cool. The contents of each tube were mixed by vortex and decanted into a spectrophotometer tube. A Bausch and Lomb Spectronic 20 was used to read transmittance at 550 nm. A representative calibration curve is given in Appendix 4. The vitamin B-6 content of the samples was calculated utilizing calibration curves which were run with each assay.

D. Vitamin recoveries

S. uvarum is known to respond equally to the three vitameric forms of vitamin B-6 (32). Sample aliquots of all foods were spiked before autoclaving with PN, PM, and PL separately and percent recoveries were determined. Percent recoveries ranged from 92 to 99% for PN, 94 to 99% for PL, and 88 to 97% for PM; vitamer recoveries

in all foods were similar.

Statistical analyses

Means ($\bar{x}$) and standard deviations (SD) were determined for all data. Analysis of variance and Duncan multiple range tests were employed in the analyses of all data to determine if any significant differences existed between sample times and between dining halls (33,34).

RESULTS AND DISCUSSION

Vitamin B-6 values of roast beef and au jus

The roast beef was subjected to more handling procedures than either the green beans or potatoes in all three dining halls; hence, additional samples were obtained at varying times in order to possibly account for vitamin B-6 losses due to extra handling. The vitamin B-6 values for each of the roast beef samples are given in Appendix 5. Fresh frozen roast beef was used in dining halls B and C while precooked frozen roast beef was utilized in dining hall A.

Vitamin B-6 values for roast beef measured at various cooking and holding times are given in Table 1. The meatpacking company from which the beef was obtained was unable to provide this researcher with any information on the vitamin B-6 content of the product. The vitamin B-6 content of raw samples of roast beef from this laboratory, (0.468 ± 0.123 mg vitamin B-6 per 100 gm, mean ±SD) was in agreement with those of other researchers (8,10,11,18). Values of 0.435 mg vitamin B-6 per 100 gm have been reported by Orr (11), 0.50 mg per 100 gm by Meyer et al. (8), and 0.51 mg per 100 gm by Polansky et al. (18). The vitamin B-6 content of raw roast beef was significantly higher ($p < 0.01$) than that of reheated to serve, and one, two, and three hours held samples in the current study, but not of the first cooked, and held before reheating samples.

As dining hall A used precooked frozen beef, its vitamin B-6 values for roast beef began to coincide with the values for dining halls B and C at the measurement called first cooking. Vitamin B-6

TABLE 1

Vitamin B-6 values of roast beef between cooking and holding times

cook/hold group	n	vitamin B-6 100 gm	vitamin B-6 retention
		mg	%
raw	6	0.468*† ±0.123	-
first cooking	9	0.419† ±0.147	92.1† ± 9.3
held before reheating	9	0.335†‡ ±0.122	73.7‡ ± 7.4
reheated to serve	9	0.261‡# ±0.106	59.3# ± 9.5
1 hr held	9	0.219‡# ±0.104	49.4#¶ ±11.6
2 hr held	9	0.196‡# ±0.103	42.8¶" ±13.8
3 hr held	9	0.151# ±0.071	32.3" ±10.4

*Values represent mean ± standard deviation.

†,‡,#,¶," Homogeneous subsets at $p < 0.01$.

values for samples taken at this sampling time were utilized in accounting for the difference between the raw vitamin B-6 values and cooked values. First cooking values obtained by this laboratory for roast beef (0.419 ± 0.147 mg vitamin B-6 per 100 gm, mean ±SD) were slightly lower than those of Meyer et al. (8) who reported a mean of 0.450 mg B-6 per 100 gm of roast beef. However, this researcher found values in the range of 0.210 to 0.625 mg B-6 per 100 gm of roast beef. The vitamin B-6 content of first cooking roast beef samples was significantly higher ($p < 0.01$) than the reheated to serve, one, two, and three hours held samples.

The next sampling time was after the beef was held but before it was reheated. This sample enabled this researcher to take into account vitamin B-6 losses due to handling and holding in the cooler. The vitamin B-6 values of roast beef held before reheating from this laboratory were 0.335 ± 0.122 mg per 100 gm (mean ±SD) with a range of 0.146 to 0.527 mg B-6 per 100 gm of beef. The vitamin B-6 content of the held before reheating samples was significantly higher, ($p < 0.01$) than the three hours held samples.

The beef was reheated before serving by pouring boiling au jus over the sliced beef, waiting a few minutes, and then repeating this process. The vitamin B-6 losses due to the reheating process were measured at this sample time. Values for the vitamin B-6 content of the roast beef at this sample time were 0.261 ± 0.106 mg B-6 per 100 gm (mean ±SD) with a range of 0.134 to 0.45 mg B-6 per 100 gm. The vitamin B-6 content of the reheated to serve beef was significantly different

($p < 0.01$) from the raw, first cooked, held before reheating, and three hours held samples.

The next three samples represent the one, two, and three hours held samples, which had been held in a hot holding unit for these lengths of time. Students eating in the dining halls could have been served a meal containing roast beef within these times, but usually not before the one hour held samples were obtained. Vitamin B-6 values of roast beef that were held for one, two, and three hours were 0.219 ± 0.104; 0.196 ± 0.103; 0.151 ± 0.071 mg B-6 per 100 gm (mean ±SD), respectively. Vitamin B-6 values for one, two, and three hour held samples did not differ significantly ($p < 0.01$) from each other, but did differ from the raw, first cooked, and held before reheating sample (Table 1). Dong et al. (10) also examined as served roast beef from a cafeteria serving line; vitamin B-6 concentrations of 0.071 to 0.237 mg per 100 gm were reported. This laboratory found as served beef to contain a range of from 0.066 to 0.429 mg vitamin B-6 per 100 gm (Appendix 5).

The vitamin B-6 content of roast beef as served in the three dining halls is shown in Table 2. The roast beef served in dining hall C had a significantly higher ($p < 0.01$) quantity of vitamin B-6 than samples from dining halls A and B. When data from all sample times were combined (Table 3), roast beef samples taken from dining hall C contained significantly more ($p < 0.01$) vitamin B-6 than did samples from dining halls A and B. Examining all the sample times as one takes into account the variability in the original beef as well as

TABLE 2

Vitamin B-6 values of roast beef as served between dining halls

dining hall	n	vitamin B-6 100 gm	vitamin B-6 retention
		mg	%
A	9	0.125* ±0.054	35.1† ± 6.7
B	9	0.156 ±0.028	42.1#† ±10.4
C	9	0.285† ±0.097	49.6# ±14.7

*Values represent mean ± standard deviation.

†Homogeneous subsets at $p < 0.01$.

‡,#Homogeneous subsets at $p < 0.05$.

TABLE 3

Vitamin B-6 values of roast beef at different dining halls

dining hall	n	vitamin B-6 100 gm	vitamin B-6 retention
		mg	%
A	18	0.210* ±0.147	54.5 ±27.2
B	21	0.239 ±0.093	63.1 ±23.5
C	21	0.392† ±0.142	69.6 ±23.0

*Values represent mean ± standard deviation.

†Significantly different at $p < 0.01$.

cooking and handling procedures practiced in the dining halls. Dining hall C received beef which originally contained more vitamin B-6 than did beef from dining halls A and B (Appendix 5) which were similar. Depending on the nutritional status of the cattle, due primarily to its feed and possibly supplementation, the raw beef values may vary greatly and thus affect further measurements.

Retention refers to the amount of vitamin B-6 that is retained in the food as opposed to the vitamin that is lost due to moist heat, light, exposure to warm air in the hot holding unit, slicing, and handling. It was expected that the roast beef would lose some vitamin B-6 at each sampling time due to the above mentioned factors. Owing to the fact that retention times generally correct for differences in the original vitamin B-6 values, this could take into account the higher vitamin B-6 values for dining hall C.

Retention of vitamin B-6 was also calculated for every sampling time using raw as the baseline values in dining halls B and C while first cooking was used as baseline in dining hall A, as these were their original measurements (Appendix 5). Vitamin B-6 retention of the first cooking and held before reheating samples were significantly different ($p < 0.01$) from each other and significantly higher ($p < 0.01$) than values of all other sampling times. Retention values for reheated to serve and one hour held samples were similar to each other ($p < 0.01$), but different from all other measurements. Two hour and three hour held sample retention values were similar ($p < 0.01$) to each other but different from those of other sampling times.

Meyer et al. (8) reported retention of vitamin B-6 in cooked roast beef to be from 45 to 52%. Values from this laboratory taken at a similar time frame ranged from 72 to 97%.

Retention values when calculated for the as served beef ranged from means of 35.1 to 49.6% (Table 2) between dining halls. The roast beef as served in dining hall C retained significantly higher ($p < 0.05$) quantities of vitamin B-6 than did roast beef from dining halls A or B. Dining hall C served the least number of students and thus handled the beef less. Roast beef samples from dining hall C also had a higher vitamin B-6 content initially (raw). The same cook did not always prepare the beef on every day the sampling occurred. This could have increased variability, but it is a usual practice in the dining halls.

Presented in Appendix 6 are the temperatures of the au jus containing roast beef as well as those of the hot holding units. There were some variations in temperature among sampling times. These variations, however, did not appear to affect the vitamin B-6 content of either the roast beef or the au jus.

The au jus the beef was heated with was also analyzed for vitamin B-6 content; individual values are given in Appendix 7. The vitamin B-6 content of some of the basic ingredients of the au jus, the beef soup base, and Gravy Master, were also analyzed and are presented in Appendix 8. Cooks in dining hall C used beef drippings and scraps in preparing the au jus while dining halls A and B did not. The quantities of these ingredients in the preparation of the au jus was variable

depending on the color judgment and taste preferences of the cooks. Also variable was the amount of au jus used in heating the beef, and time dependent, how much au jus was left in the kettle. These were all factors that could have affected the vitamin B-6 content of the au jus. These were ordinary occurrences in the dining halls.

The vitamin B-6 content of the au jus obtained at various sampling times is given in Table 4. The vitamin content of raw au jus (before being added to the beef) was significantly lower ($p < 0.01$) than that of all other sampling times. The vitamin B-6 content of as cooked and one hour held au jus were similar to each other. The vitamin B-6 content of the one, two, and three hour held samples were also similar to each other.

When the vitamin B-6 content of the au jus from the as served measurements (one, two, and three hours held) were examined, au jus from dining hall C was significantly higher ($p < 0.01$) than au jus from dining halls A and B (Table 5). The vitamin B-6 content of au jus from dining hall C was significantly higher ($p < 0.05$) than that of au jus from dining halls A and B when all sampling times were combined (Table 5). As with the roast beef, when original vitamin B-6 content was higher, so were retention values.

The au jus gained approximately 0.08 mg vitamin B-6, while roast beef lost about 0.286 mg. The increase in the vitamin B-6 content of the au jus during holding procedures could account for roughly 29% of the vitamin B-6 content lost by the roast beef.

TABLE 4

Vitamin B-6 values of au jus between cooking and holding times

cook/hold group	n	Vitamin B-6 100 gm	Vitamin B-6 gain
		mg	%
raw	9	0.038*† ±0.026	-
as cooked	9	0.083‡ ±0.027	186.3¶ ±192.8
1 hr held	9	0.111†# ±0.020	306.8¶" ±227.2
2 hr held	9	0.125# ±0.032	360.2" ±272.8
3 hr held	9	0.122# ±0.046	394.9" ±375.7

*Values represent mean ± standard deviation.

†Significantly different from values of other groups, $p < 0.01$.

‡,#Homogeneous subsets, $p < 0.05$.

¶,"Homogeneous subsets, $p < 0.01$.

TABLE 5

Vitamin B-6 values of au jus as served between dining halls

dining hall	n	vitamin B-6 100 gm	vitamin B-6 gain
		mg	%
A	9	0.112* ±0.019	465.1 ±348.4
B	9	0.097 ±0.023	273.7 ±174.6
C	9	0.148† ±0.035	323.1 ±312.2

*Values represent mean ± standard deviation.

†Significantly higher at $p < 0.01$.

Retention of vitamin B-6 in the au jus was referred to as percent gain. When looking at each sample time separately, as cooked au jus gain values were similar to one hour held au jus values but significantly lower ($p < 0.01$) than all other sample times (Table 4). The gain values for the three dining halls at all sampling times as well as for as served were similar (Tables 5 and 6). The standard deviations, however, were quite large.

Vitamin B-6 when held in a warm aqueous medium had the tendency to leach out from the solid (roast beef) to the liquid (au jus). This property of vitamin B-6 was expected, but the amount transferred from roast beef to au jus had not previously been reported (32).

Quantities of au jus, such as sampled in this study, are commonly used in large foodservice units; however, their nutrient contents have not been measured by earlier researchers. Reports of vitamin B-6 content or losses were not found by this researcher in the literature. Considering that the au jus was used primarily to heat the roast beef and keep it moist; none was ladled over the beef on a student's plate unless requested; hence, au jus was not deemed to provide significant quantities of vitamin B-6 in the as served roast beef.

Vitamin B-6 values of green beans and pot liquor

Samples of green beans were selected from the time the cans were opened until being hot held for three hours. The vitamin B-6 values for each sample of beans are presented in Appendix 9.

Several samples of green beans were selected to determine the average serving size; however, these samples were not used for vitamin

TABLE 6

Vitamin B-6 values of au jus at different dining halls

dining hall	n	vitamin B-6 100 gm	vitamin B-6 gain
		mg	%
A	15	0.088* ±0.039	334.5 ±334.5
B	15	0.079 ±0.036	186.5 ±177.6
C	15	0.120† ±0.050	227.9 ±278.1

*Values represent mean ± standard deviation.

†Significantly higher at $p < 0.05$.

analyses. These samples were selected in the same manner as the analyzed samples, but were only weighed. The average serving size was determined to be 88 gm. Similar statistical patterns were obtained when data were expressed on the 100 gm basis as well as on the serving or 88 gm basis.

The vitamin B-6 values of green beans between cooking and holding times are shown in Table 7. The vitamin B-6 content of raw samples from this laboratory (0.052 ± 0.009 mg B-6 per 100 gm, mean ±SD) were within the range of values published by Orr (11), 0.040 mg B-6 per 100 gm; Polansky (17), 0.073 to 0.082 mg B-6 per 100 gm; and Kabir et al. (35), 0.028 mg B-6 per 100 gm. Raw is the term given to the beans as taken from the can. The vitamin B-6 content of raw green beans was significantly higher ($p < 0.01$) than the one, two, and three hours held samples, but similar to the as cooked sample. The as cooked sample was significantly higher ($p < 0.01$) than the three hours held sample.

As previously stated, the one, two, and three hour held samples encompass the time when a student could be served green beans as part of a meal. These are referred to as as served samples. Vitamin B-6 values for the one, two, and three hour held samples from this laboratory were respectively 0.033 ± 0.011; 0.029 ± 0.011; and 0.023 ± 0.010 mg B-6 per 100 gm, mean ±SD . Prusa et al. (9) sampled cooked green beans from onsite, central, and satellite kitchens; values of 0.014 and 0.015 mg B-6 per 100 gm were reported.

When the vitamin B-6 values of as served sample times were compared between dining halls (Table 8), samples from dining halls A and C

TABLE 7

Vitamin B-6 values of green beans between cooking and holding times

cook/hold group		vitamin B-6 100 gm	vitamin B-6 serving	retention
		← mg →		%
raw	9	0.052 ±0.009 *†	0.046 ±0.008 ¶	-
as cooked	9	0.040 ±0.010 †‡	0.035 ±0.009 ¶ //	76.5 ±14.7 ††
1 hr held	9	0.033 ±0.011 ‡#	0.029 ±0.010 //**	63.7 ±18.7 ††‡‡
2 hr held	9	0.029 ±0.011 †#	0.026 ±0.020 //**	56.3 ±18.1 ††‡‡
3 hr held	9	0.023 ±0.010 #	0.020 ±0.009 **	42.9 ±21.1 ‡‡

*Values represent mean ± standard deviation.

†,‡,#,¶,//,**,††,‡‡Homogeneous subsets at $p < 0.01$.

TABLE 8

Vitamin B-6 values of green beans as served between dining halls

dining hall	n	vitamin B-6 100 gm	vitamin B-6 serving	retention
		← mg →		%
A	9	0.035*† ±0.009	0.031 ±0.008	74.4# ±11.8
B	9	0.029†‡ ±0.013	0.025 ±0.012	48.2¶ ±18.1
C	9	0.021†‡ ±0.006	0.018 ±0.006	40.2¶ ±13.6

*Values represent mean ± standard deviation.

†,‡,#,¶Homogeneous subsets at $p < 0.01$.

were significantly different ($p < 0.01$) from each other but not from dining hall B. Possible reasons for this finding were that 1) dining halls A and C are the largest and smallest respectively, 2) dining hall A used only two of the three lot number of green beans while dining halls B and C used all three, 3) cooking and handling practices in dining hall A may have been more efficient in preserving nutrients, and 4) dining hall A is the newest on campus and its equipment the least worn.

However, as shown in Table 9, when all sampling times for green beans were combined within dining halls, green beans from dining hall C contained significantly less ($p < 0.05$) vitamin B-6 than did green beans from dining halls A and B. Variability of the raw green beans and the canning process may account for some of these differences.

Retention of vitamin B-6 in these green beans was also calculated using raw as the baseline. Some of the vitamin was lost due to moist heat, light, and exposure to warm air in the hot holding units. Previous authors (4,10,11,14,17) did not present retention values for vitamin B-6 in green beans. Individual sample retention percentages are listed in Appendix 9.

The as cooked samples of green beans retained significantly more ($p < 0.01$) vitamin B-6 than did the three hour held samples. One, two, and three hour held samples were similar to each other (Table 7). When as served samples of green beans were compared between dining halls, green beans from dining hall A retained significantly higher ($p < 0.01$) amounts of vitamin B-6 than did green beans from dining halls B and C.

TABLE 9

Vitamin B-6 values of green beans at different dining halls

dining hall	n	vitamin B-6 100 gm	vitamin B-6 serving	retention
		← mg →		%
A	15	0.039* ±0.010	0.035 ±0.009	83.1 ±14.5
B	15	0.038 ±0.017	0.034 ±0.008	63.4 ±25.9
C	15	0.029† ±0.013	0.026‡ ±0.012	56.9# ±26.4

*Values represent mean ± standard deviation.

†,‡,#Significantly lower at $p < 0.05$.

However, when all sample times were compared, green beans from dining hall C retained significantly less ($p < 0.05$) vitamin B-6 than did those from dining halls A and B (Table 9). The same cook did not prepare the green beans for each sample day, but this is a usual practice which could lead to some variability.

Temperatures of the pot liquor containing green beans as well as the hot holding units are listed in Appendix 10. There were some variations in temperature over sampling times, however, it did not seem to affect the vitamin B-6 content of the green beans or pot liquor.

Pot liquor referred to the liquid the beans were canned in as well as that used (along with oleomargarine) to heat the beans. The vitamin B-6 values of pot liquor samples are given in Appendix 11.

As shown in Table 10, the vitamin B-6 content of raw and three hour held samples were similar to each other but raw samples contained significantly lower ($p < 0.01$) amounts of the vitamin than as cooked, one, and two hour held samples. The as served samples of pot liquor from dining halls B and C contained significantly different ($p < 0.01$) quantities of the vitamin; the vitamin content of samples from dining halls B and C were similar to samples from dining hall A (Table 11). However, when all sample times were combined and the values compared between dining halls, no significant differences were noted (Table 12).

After the green beans were opened and placed in the steam kettles, employees from dining hall B drained some of the pot liquor and replaced it with water. Cooks in dining halls A and C did not utilize this

TABLE 10

Vitamin B-6 values of pot liquor between cooking and holding times

cook/hold group	n	vitamin B-6 100 gm	vitamin B-6 gain
		mg	%
raw	9	0.016*† ±0.008	-
as cooked	9	0.025‡ ±0.005	186.1 ± 75.9
1 hr held	9	0.024‡ ±0.006	188.8 ± 98.2
2 hr held	9	0.024‡ ±0.005	181.6 ± 86.6
3 hr held	9	0.023†‡ ±0.004	166.7 ±103.7

*Values represent mean ± standard deviation.

†,‡Homogeneous subsets, $p < 0.01$.

TABLE 11

Vitamin B-6 values of pot liquor as served between dining halls

dining hall	n	vitamin B-6	
		100 gm	gain
		mg	%
A	9	0.024*†‡ ±0.004	130.0# ± 82.4
B	9	0.020‡ ±0.003	231.9¶ ± 71.8
C	9	0.027† ±0.006	175.1¶# ±102.0

*Values represent mean ± standard deviation.

†,‡Homogeneous subsets at $p < 0.01$.

#,¶Homogeneous subsets at $p < 0.05$.

TABLE 12

Vitamin B-6 values of pot liquor at different dining halls

dining hall	n	vitamin B-6 100 gm	vitamin B-6 gain
		mg	%
A	15	0.024* ±0.006	112.0 ± 93.8
B	15	0.018 ±0.005	182.9 ±111.4
C	15	0.025 ±0.006	139.0 ±110.8

*Values represent mean ± standard deviation.

practice. As served samples of green beans and pot liquor from dining hall C had a significantly higher ($p < 0.01$) initial amount of vitamin B-6 (Appendices 9 and 11).

Retention of vitamin B-6 in the pot liquor was referred to as percent gain. When looking at each sample time separately, no significant differences in retention were observed (Table 10). The same was true when retention of the vitamin was examined between dining halls, combining all sample times (Table 12). However, when vitamin B-6 retention in as served pot liquor between dining halls was examined, retention of the vitamin in pot liquor from dining hall B was significantly higher ($p < 0.01$) than retention of the vitamin in pot liquor from dining halls A and C (Table 11). As noted earlier (32), vitamin B-6 had the tendency to leach out from the green beans (solid) to the pot liquor (liquid). Considering that the pot liquor was not generally served to the students unless requested and its vitamin B-6 content was minimal, pot liquor did not provide a significant amount of vitamin B-6.

Vitamin B-6 values of baked potatoes

As with the green beans, five sampling times were utilized for the baked potatoes. The vitamin B-6 values of individual samples of potatoes are presented in Appendix 12. Cooks in dining hall A used room sized, rotary bakery ovens to cook their potatoes, while those in dining hall B utilized a commercial steamer and those in dining hall C employed conventional ovens. The vitamin B-6 content of the potatoes was analyzed in a variety of ways - as a serving, which constituted a

whole potato of varying weights (mean of eight potatoes), 100 gm of whole potato, and as 100 gm of both peel and flesh.

The vitamin B-6 content of whole baking potatoes at various cooking and holding times were similar (Table 13). The mean vitamin B-6 content of raw baking potatoes was 0.260 mg per 100 gm. Polansky (17) reported finding 0.233 mg B-6 per 100 gm of whole raw potatoes; Orr (11), 0.25 mg vitamin B-6 per 100 gm; Augustin (19,21,22,23) reported ranges of from 0.13 to 0.60 mg vitamin B-6 per 100 gm; and Page and Hanning (20) reported a range of 0.13 to 0.42 mg of the vitamin per 100 gm of raw potatoes.

On only one sample day was a box of potatoes received with nutritional labeling. A figure of 0.27 mg vitamin B-6 per 100 gm was listed on the label. This figure fell within the range of raw potato vitamin B-6 values obtained in this study (0.179 - 0.379 mg B-6 per 100 gm).

The vitamin B-6 content of as cooked potatoes in this study (0.253 ± 0.069 mg per 100 gm, mean ±SD) was in agreement with the value of 0.24 mg per 100 gm reported by Augustin (23). Students in the present study could be served potatoes referred to as one, two, and three hour held potatoes; their mean vitamin B-6 content was 0.232, 0.231, and 0.225 mg per 100 gm, respectively. These values were somewhat higher than as served values ranging from 0.104 to 0.172 mg vitamin B-6 per 100 gm reported by Dong et al. (10).

The weights of individual samples of whole potatoes ranged from 116.4 to 231.4 gm at various cooking and holding times (Appendix 12).

TABLE 13

Vitamin B-6 values of whole baking potatoes between cooking and holding times

cook/hold group	n	wt	vitamin B-6 content 100 gm	vitamin B-6 content serving	vitamin B-6 retention 100 gm	vitamin B-6 retention serving
		gm	← mg →		← % →	
raw	9	206.4* ± 16.5	0.260 ±0.065	0.529† ±0.112	-	-
as cooked	9	191.7 ± 16.5	0.253 ±0.069	0.477†‡ ±0.107	97.0 ±11.2	90.0# ±11.6
1 hr held	9	187.3 ± 19.1	0.232 ±0.065	0.430†‡ ±0.119	88.0 ±14.1	80.3#¶ ±13.5
2 hr held	9	186.0 ± 21.4	0.231 ±0.062	0.424†‡ ±0.112	88.3 ±11.4	79.7#¶ ±12.6
3 hr held	9	174.4 ± 27.4	0.225 ±0.071	0.377‡ ±0.066	88.7 ±23.5	73.1¶ ±17.1

*Values represent mean ± standard deviation.

†,‡Homogeneous subsets at $p < 0.01$.

#,¶Homogeneous subsets at $p < 0.05$.

Whole potatoes whose mean weights ranged from 174.4 to 206.4 gm had mean vitamin B-6 values of 0.377 to 0.529 mg per average potato (Table 13). Only the raw and three hour held sample values for vitamin B-6 were significantly different ($p < 0.01$) from each other; the vitamin content of samples taken at other cooking and holding times was similar.

When as served samples were combined and examined between dining halls (Table 14), there were no significant differences between either the 100 gm or the whole serving of potatoes between dining halls. When all sample times were combined (Table 15) and examined between dining halls, there was a significant difference between the vitamin B-6 content per serving of potatoes but not per 100 gm. The vitamin B-6 content of whole potatoes from dining halls B and C but not A were significantly different ($p < 0.05$) from each other when data were expressed on the 100 gm basis. The vitamin B-6 content of samples from dining halls B and C were significantly different ($p < 0.05$) from each other, but both were similar to dining hall A.

Retention of vitamin B-6 in potatoes was also calculated; individual values are given in Appendix 12. There was no significant difference ($p < 0.01$) between the vitamin B-6 retention at various cooking and holding times when data were expressed per 100 gm of potatoes, but there was a significant difference ($p < 0.05$) in the vitamin B-6 retention of whole potatoes sampled between the raw and three hour held observations when data were expressed per serving size (Table 13). The as cooked, one, and two hour held samples were

TABLE 14

Vitamin B-6 values of whole baking potatoes

as served between dining halls

dining hall	n	wt	vitamin B-6 content 100 gm	vitamin B-6 content serving	vitamin B-6 retention 100 gm	vitamin B-6 retention serving
		gm	← mg →		← % →	
A	9	181.5 ± 26.7	0.226* ±0.062	0.403 ±0.110	98.1 ±14.2	88.7† ±15.8
B	9	189.5 ± 15.9	0.206 ±0.048	0.384 ±0.075	82.4 ±13.2	73.8†‡ ± 8.7
C	9	176.6 ± 24.9	0.256 ±0.074	0.444 ±0.114	84.4 ±18.5	70.7‡ ±11.7

*Values represent mean ± standard deviation.

†,‡Homogeneous subsets at $p < 0.01$.

TABLE 15

Vitamin B-6 values of whole potatoes and 100 gm samples at different dining halls

dining halls	n	wt	vitamin B-6 content 100 gm	vitamin B-6 content serving	vitamin B-6 retention 100 gm	vitamin B-6 retention serving
		gm	← mg →		← % →	
A	15	187.0* ± 24.0	0.227†‡ ±0.057	0.419 ±0.101	79.4# ±43.0	72.7 ±40.2
B	15	195.8 ± 17.0	0.219‡ ±0.056	0.425 ±0.100	67.2¶ ±36.3	61.3 ±32.9
C	15	184.6 ± 24.7	0.274† ±0.071	0.500 ±0.124	70.6#¶ ±39.6	59.8 ±32.9

*Values represent mean ± standard deviation.

†,‡,#, Homogeneous subsets at $p < 0.05$.

similar ($p < 0.05$) in their retention of the vitamin no matter on what basis data were calculated. When comparing the vitamin B-6 retention in 100 gm of whole baked potatoes as served between dining halls (Table 14), no difference was found. However, when data were expressed on the serving basis, the vitamin B-6 retention in potatoes from dining halls A and C were significantly different ($p < 0.01$) from each other. The trend was reversed, however, when data from all sample times were combined and examined between dining halls (Table 15). No significant difference was found between dining halls in the vitamin B-6 retention of whole baking potatoes when data were expressed on the serving basis. The vitamin B-6 retention of potatoes from dining halls A and B were significantly different ($p < 0.05$) from each other when data were expressed per 100 gm. Augustin et al. (23) reported finding retention of vitamin B-6 in baked potatoes to be from 88 to 109%, while Page and Hanning (20) reported retention of the vitamin to be in a range of 65 to 111.5%.

Temperatures of the hot holding units are given in Appendix 14. The variations in temperature did not seem to affect vitamin B-6 retention in the potatoes.

The vitamin B-6 values of individual samples of peel and flesh from potatoes are reported in Appendix 13. Presented in Table 16 are the vitamin B-6 values of peel and flesh of potatoes between cooking and holding times. No significant differences were found between sample times for vitamin B-6 content in either peel or flesh. Vitamin B-6 values have been reported for peel and flesh from raw potatoes;

Polansky (17) found 0.15 mg vitamin B-6 and 0.24 mg per 100 gm of peel and flesh, respectively; Augustin et al. (21) reported 0.21 mg and 0.22 mg per 100 gm of peel and flesh, respectively. Values from this laboratory for vitamin B-6 in raw flesh ranges from 0.192 to 0.399 mg B-6 per 100 gm and in raw peel 0.135 to 0.356 mg per 100 gm. Polansky (17) also reported finding 0.42 mg vitamin B-6 per 100 gm of cooked potato peel and 0.25 mg B-6 per 100 gm of cooked potato flesh. Values from this laboratory for as cooked potato peel ranged from 0.132 to 0.346 mg per 100 gm and for cooked potato flesh, 0.149 to 0.372 mg B-6 per 100 gm (Appendix 13).

When as served (one, two, and three hour held samples) were compared between dining halls, no significant differences in vitamin B-6 content were found in either peel or flesh (Table 17). The vitamin B-6 values of all samples of potato peel and flesh between dining halls are given in Table 18. There was not a significant difference between the vitamin B-6 content of peel between dining halls, but the vitamin content of potato flesh from dining halls A and C but not B were significantly different ($p < 0.05$).

Retention of vitamin B-6 was also determined for both potato peel and flesh. There was no significant difference in the vitamin B-6 retention in peel, either in separate sample times (Table 16), all sample times combined (Table 18), or in as served samples (Table 17). Vitamin B-6 retention of potato flesh did not differ significantly between sampling times (Table 16). The retention of vitamin B-6 in potato flesh from dining halls B and C but not A when all sampling

TABLE 16

Vitamin B-6 values of peel and flesh of baking potatoes between cooking and holding times

cook/hold group	n	vitamin B-6 content (100 gm) peel	vitamin B-6 content (100 gm) flesh	vitamin B-6 retention peel	vitamin B-6 retention flesh
		← mg →		← % →	
raw	9	0.245* ±0.079	0.275 ±0.071	-	-
as cooked	9	0.248 ±0.079	0.258 ±0.071	102.9 ± 23.8	95.4 ±25.3
1 hr held	9	0.232 ±0.072	0.230 ±0.074	97.2 ± 27.2	85.3 ±16.1
2 hr held	9	0.240 ±0.062	0.225 ±0.066	100.0 ± 23.3	82.9 ±22.6
3 hr held	9	0.222 ±0.054	0.205 ±0.049	94.9 ± 19.5	78.1 ±25.5

*Values represent mean ± standard deviation.

TABLE 17

Vitamin B-6 values of peel and flesh of baking potatoes as served between dining halls

dining hall	n	vitamin B-6 content (100 gm) flesh (mg)	vitamin B-6 content (100 gm) peel (mg)	vitamin B-6 retention flesh (%)	vitamin B-6 retention peel (%)
A	9	0.213* ±0.054	0.237 ±0.082	82.3†‡ ± 21.6	86.3 ±19.7
B	9	0.207 ±0.051	0.207 ±0.050	67.8‡ ± 9.9	98.0 ± 13.8
C	9	0.239 ±0.080	0.249 ±0.044	94.2† ±23.4	107.8 ± 28.9

*Values represent mean ± standard deviation.

†,‡Homogeneous subsets at $p < 0.01$.

TABLE 18

Vitamin B-6 values of peel and flesh of baking potatoes at different dining halls

dining hall	n	vitamin B-6 content (100 gm) peel (mg)	vitamin B-6 content (100 gm) flesh (mg)	vitamin B-6 retention peel (%)	vitamin B-6 retention flesh (%)
A	15	0.234* ±0.077	0.220† ±0.050	71.7 ±40.7	68.4#¶ ±39.4
B	15	0.216 ±0.060	0.244†‡ ±0.064	77.3 ±41.4	59.5¶ ±33.3
C	15	0.261 ±0.058	0.272‡ ±0.080	88.1 ±52.9	77.1# ±47.0

*Values represent mean ± standard deviation.

†,‡,#, ¶ Homogeneous subsets at $p < 0.05$.

times (Table 18) were combined were significantly different ($p < 0.05$). When as served samples were examined, the vitamin B-6 retention of potato flesh from dining halls B and C but not A differed significantly ($p < 0.01$) from each other.

Analyses of data from the microbiological analysis of baked and raw potato peel and flesh proved to be an interesting challenge. Previously mentioned authors (10,11,17,19-23) presented a wide range of vitamin B-6 values for raw as well as cooked samples, with calculated retentions of vitamin B-6 to be at times over 100%. There are a variety of reasons for this occurrence.

The cultural variety of potatoes affects the vitamin B-6 content. Other factors affecting vitamin B-6 content in potatoes are growing location in the field and where more or less fertilizer and water fell, in the field. Sorting of potatoes may also cause differences; the sizes, however, were fairly uniform in the packing boxes, and the potatoes were again randomly sorted by this researcher. Storage temperatures and humidity can also affect the vitamin content of potatoes and was not controlled.

Vitamin B-6 content of potatoes increases with increasing storage time as the bound vitamin B-6 is released (19,20). As potato boxes were not dated, it could not be determined how long potatoes utilized in the dining halls had been stored. Realizing that not everyone consumes the peel of potatoes, flesh and peel were analyzed separately in this study.

Augustin et al. (21) also mentioned peel thickness as a variable. The current researcher separated the peel from the flesh in a standard manner. For comparison, it is not possible to say that another researcher who reported flesh and peel vitamin B-6 values did so in the same manner.

In all dining halls potatoes were washed in tubs of warm water and skins either pierced or soft spots cut off. Approximately 8 people in each dining hall were responsible for this practice and since it was a usual occurrence it was not controlled. Cooks in dining hall B steamed potatoes whereas those in A and C baked potatoes; this did not seem to have a consistent effect on vitamin values.

The following foodservice practices should result in higher retention of vitamin B-6 in the selected foods: 1) the beef could be sliced and held under refrigeration in cold au jus, with reheating occurring by quick high pressure steaming, rather than being hot held; 2) beans could be heated by high pressure steaming, in small batches as needed rather than heating all at once and hot held; and 3) that pot liquor and au jus (mainly the au jus) be saved for future use as bases for soups, sauces, and gravies, in place of other commonly used liquids. More vitamin B-6 would be retained if cooking and holding times are held to a minimum.

CONCLUSION

The vitamin B-6 content of the three selected foods was decreased by cooking and holding procedures utilized at the three dining halls. The cooking and holding practices were somewhat different in each of the three dining halls. However, there was no pattern of any one dining hall having foods with consistently higher retention values of vitamin B-6.

Roast beef from each dining hall lost significant quantities of vitamin B-6 from the raw values as compared to the three hours held samples. Precooked frozen roast beef, as utilized in dining hall A contained significantly ($p < 0.01$) less total vitamin B-6 than did fresh frozen roast beef utilized at both dining halls B and C. Retention of vitamin B-6 in precooked roast beef was also significantly lower ($p < 0.01$) than in the fresh frozen roast beef.

The initial amount of vitamin B-6 in the canned green beans was variable. Vitamin B-6 was lost from each sample as cooking and holding times progressed. Samples from dining hall C initially contained significantly less ($p < 0.05$) vitamin B-6 than did green bean samples from dining halls A and B. Significantly less ($p < 0.05$) vitamin B-6 was retained in samples from dining hall C also.

Pot liquor and au jus gained in total vitamin B-6 content as they were held with the green beans and roast beef, respectively. The difference was not significant due to the large standard deviations.

Whole baked potatoes from all three dining halls did not differ significantly in vitamin B-6 content. The vitamin content of raw

potatoes was significantly higher ($p < 0.01$) than that of three hour held samples; however, potatoes from other cooking and holding times had similar vitamin B-6 concentrations.

The vitamin B-6 content of all three selected foods decreased with institutional cooking and holding practices utilized in these dining halls. The vitamin B-6 content of these foods was slightly higher when the foods were held for shorter periods of time in hot holding units.

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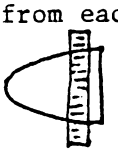
APPENDIX 1

Sample collection

Roast beef at dining halls A and C

At about 1:00 pm come to 301 Wallace and collect the box that is packed and labeled for your assigned dining hall. About 1:30 the cook will be slicing the beef. Take five small serving pans, and label them one through five. From 33 different quarter rounds of the beef, as the cook slices it, select three slices from each piece from the approximate area between the solid lines.  Rotate slices in the five pans until there are 20 per pan. Cover pans with kitchen paper. Place in cooler.

At about 2:20 take out pan number one, this is for the held before reheating sample. Label as such, along with the date, dining hall, and that it is beef. Place eight slices in a double plastic bag, cover with foil, and put inside another bag. Place sample in crushed ice. Remove tape, give pan back to cook.

Now the au jus will be in a steamkettle, take and record the temperature and then sample. Two of the large test tubes three-quarters full is a sample. Label as with beef, place in ice in cooler.

By this time, the cook should be heating the beef to go to the serving lines. Take your four pans two through five out of the cooler and the cook will heat them for you. In pan two, place the thermometer, take pans three, four, and five to the hot holding unit. It will be labeled "Vitamin Study", and it has a thermometer inside it, read the

temperature. Record the temperature of pan two and of the hot holding unit. Take eight random slices of beef, seal as earlier, and label, do the same with the au jus. In one, two, and three hours from now, repeat the process. Samples are to be left in ice in the cooler; they will be picked up by 7:00 pm.

Roast beef at dining hall B

As in collecting from dining halls A and C, come to 301 Wallace to collect your equipment for dining hall B, at about 2:00 pm. Samples will be in labeled pans in the cooler. Begin collecting following directions starting at 2:20 for dining halls A and C.

Green beans at all dining halls

At about 1:45 pm come to 301 Wallace and collect the packed box that is labeled for your assigned dining hall. In the dining hall at about 2:15, the green beans will be in a steamkettle, but cold; get the two lined cartons that are labeled raw, take six random slotted serving spoons full and place in one carton; repeat process. Now get the two similarly labeled test tubes, fill them three-quarters full with pot liquor. Place these samples in crushed ice in the cooler. Now the cook will boil the beans. When he/she tells you its cooked, give the cook the pans labeled one through four. Place the thermometer in pan one. Place pans two, three, and four into the labeled hot holding unit; there is a thermometer inside. Read and record temperatures of both pot liquor with beans and of the holding unit. As before, sample the beans, putting six spoons full into the labeled container and the test tubes should be three-quarters full of pot liquor. Repeat this

procedure in one, two, and three more hours. Samples will be picked up before 7:00 pm. Please leave all samples in plenty of ice in the cooler.

Potatoes at all dining halls

At about 2:45 pm come to 301 Wallace and collect the box that is packed and labeled for your assigned dining hall. At about 3:00 the potatoes will be cooked. Pans are labeled one and two. From pan one take the first sample, label with date, dining hall, time, and that it is potatoes. Wrap the eight potatoes in foil, place in the large plastic bag. Place sample in crushed ice in the cooler. In one, two, and three hours repeat the process, first with pan one, then the last two samples from pan two. Keep all samples in crushed ice in the cooler. They will be picked up before 7:00 pm.

APPENDIX 2

Reagent preparation

YM agar

41 gm/L Bacto YM agar, place 5 ml in each screw top test tube. Boil while shaking constantly. Autoclave 15 minutes, 121°C, and 15 psi. Cool in slanted position at room temperature. Store at 5°C.

Pyridoxine Y media for inoculum

Dissove 0.54 gm pyridoxine Y media in 20 ml d/d water. Make fresh for each assay.

Saline

Dissolve 0.9 gm NaCl in a dl; pour 10 ml into a test tube, cap, and autoclave 15 minutes at 121°C and 15 psi. Store at 5°C.

0.055 N HCl

4.6 ml concentrated HCl, brought to 1 L volume with d/d water.

6 N KOH

138 gm KOH, brought to 500 ml volume with d/d water; stir to dissolve.

Pyridoxine Y media for sample assay

To prepare 150 tubes, dissolve 39.8 gm pyridoxine Y media in 750 ml d/d water. Stir to dissolve. Make fresh for each assay.

Stock standard

25 mg PN HCl in 250 ml 25% ETOH. Store in dark bottle at 5°C.

Working standard

Take 1 ml from stock standard, dilute to 1 dl with d/d water, this is #2. Take 1 ml from #2, dilute to 1 dl with d/d water, this is #3. Take 5 ml of #3, dilute to 25 ml with d/d water, this is the standard that produces 0.5, 1, 2, 4 ng per tube with 250 µl, 500 µl, 1 ml, and 2 ml standard.

Spiking standards

25 mg pyridoxal HCl in 250 ml 25% ETOH. 25 mg pyridoxamine dihydrochloride in 250 ml 25% ETOH. Store in dark bottles at 5°C.

APPENDIX 3

Chemicals and vendors

American Type Culture Collection (Rockville, MD)
- Saccharomyces uvarum 9080

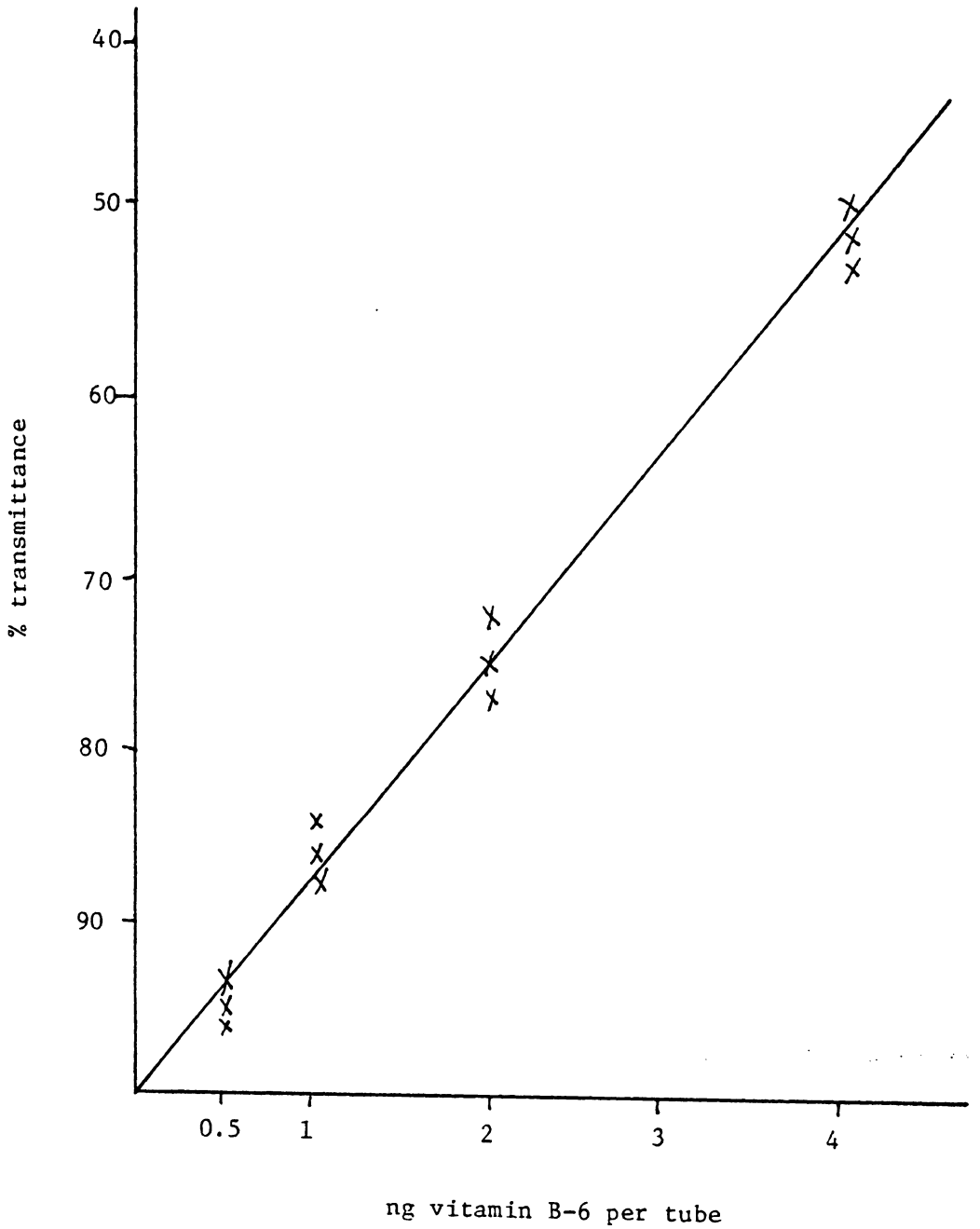
Difco Laboratories (Detroit, MI)
- Bacto YM agar 07-2-01
- Pyridoxine Y medium 0951-15-2

Fisher Scientific Company (Raleigh, NC)
- NaCl ACS
- HCl ACS
- Acetic acid, glacial ACS
- KOH ACS

Sigma Chemical Company (St. Louis, MO)
- Pyridoxine HCL P 9755
- Pyridoxal HCl P 9130
- Pyridoxamine dihydrochloride P 9380

APPENDIX 4

Vitamin B-6 calibration curve for microbiological assay



APPENDIX 5

Vitamin B-6 values of individual roast beef samples

		raw	first cooking		held before reheating		as reheated		1 hr held		2 hr held		3 hr held	
		vitamin B-6												
collection date	dining hall	mg/ 100 gm	mg/ 100 gm	retention %	mg/ 100 gm	retention %	mg/ 100 gm	retention %	mg/ 100 gm	retention %	mg/ 100 gm	retention %	mg/ 100 gm	retention %
3-29	C	.485	.478	97	.299	62	.284	59	.275	57	.267	55	.147	30
4-7	B	.379	.312	72	.265	64	.233	61	.158	42	.140	37	.101	27
4-7	C	.595	.536	90	.456	77	.348	58	.292	49	.247	41	.164	27
4-19	A	-	.210	-	.146	69	.139	66	.075	36	.071	34	.066	31
4-19	B	.408	.362	89	.315	74	.189	46	.182	45	.167	41	.152	37
4-19	C	.624	.597	96	.527	84	.450	72	.429	69	.420	67	.321	51
4-27	B	.315	.267	85	.256	81	.223	71	.201	64	.156	50	.147	36
5-10	A	-	.289	-	.216	75	.134	46	.132	46	.121	42	.114	39
5-31	A	-	.625	-	.464	74	.345	55	.231	37	.174	28	.148	24

APPENDIX 6

Temperatures of hot holding units and

au jus containing roast beef in °C*

	dining hall								
	A			B			C		
date	4-19	5-10	5-31	4-7	4-19	4-27	3-29	4-7	4-19
cook/hold group									
reheated to serve	85/70	110/64	120/68	70/65	78/56	70/72	70/78	75/62	79/59
1 hr held	75/62	90/62	78/66	68/60	68/52	70/55	65/60	84/55	72/57
2 hr held	77/60	90/78	75/64	65/54	73/53	74/60	68/62	84/59	72/57
3 hr held	82/60	104/78	74/64	88/70	83/57	92/61	70/58	86/61	72/57

*H/B; H = hot holding units and B = au jus containing roast beef.

APPENDIX J

Vitamin B-6 values of individual au jus samples

collection date	dining hall	raw	as cooked		1 hr held		2 hr held		3 hr held	
		vitamin B-6								
		mg/100 gm	mg/100 gm	% gain	mg/100 gm	% gain	mg/100 gm	% gain	mg/100 gm	% gain
3-29	C	.022	.098	345	.143	550	.165	650	.220	900
4-7	B	.050	.114	128	.105	110	.098	96	.051	2
4-7	C	.043	.108	151	.127	195	.183	326	.126	193
4-19	A	.018	.051	183	.105	481	.094	422	.101	461
4-19	B	.024	.046	42	.074	208	.098	308	.133	454
4-19	C	.094	.107	14	.124	32	.129	37	.117	25
4-27	B	.020	.053	165	.113	465	.102	410	.102	410
5-10	A	.060	.076	26	.108	80	.130	116	.098	63
5-31	A	.013	.094	623	.096	638	.127	877	.149	1046

APPENDIX 8

Vitamin B-6 values of ingredients used in making au jus

ingredient	vitamin B-6
	mg/100 gm
dry soup mix	0.272
reconstituted soup mix*	0.040
Gravy Master	0.020

*Prepared per package directions.

APPENDIX 9

Vitamin B-6 values of individual green bean samples

collection date	dining hall	raw		as cooked			1 hr held			2 hr held			3 hr held		
		vitamin B-6													
		100 gm	serving	100 gm	serving	retention	100 gm	serving	retention	100 gm	serving	retention	100 gm	serving	retention
		mg		mg		%	mg		%	mg		%	mg		%
2-19	C	.046	.040	.030	.026	65	.028	.025	61	.021	.018	46	.017	.015	37
2-24	B	.048	.042	.032	.028	66	.025	.022	52	.019	.016	40	.010	.008	21
3-28	A	.039	.034	.036	.032	92	.032	.028	82	.030	.023	77	.025	.022	64
3-28	B	.065	.057	.058	.051	89	.053	.047	82	.044	.039	68	.028	.025	43
3-28	C	.048	.042	.028	.025	58	.017	.015	35	.016	.014	33	.011	.009	23
4-2	B	.066	.058	.042	.037	64	.032	.028	48	.031	.027	47	.022	.019	33
4-2	C	.058	.051	.040	.035	69	.030	.026	47	.027	.024	47	.022	.019	38
4-7	A	.055	.048	.053	.047	96	.050	.044	91	.048	.042	87	.044	.039	80
4-14	A	.047	.041	.042	.037	89	.033	.029	70	.029	.026	62	.027	.024	57

APPENDIX 10

Temperatures of hot holding units and pot liquor containing green beans in °C*

	dining hall								
	A			B			C		
date	3-28	4-7	4-14	2-24	3-28	4-2	2-19	3-28	4-2
cook/hold group									
as cooked	82/96	79/94	85/97	86/92	76/92	91/85	68/92	59/67	85/82
1 hr held	80/75	83/77	90/82	84/80	74/72	71/67	67/61	59/59	85/70
2 hr held	68/72	79/74	85/70	88/74	78/76	71/64	65/56	60/57	80/71
3 hr held	70/68	85/73	87/68	94/78	76/68	70/60	68/56	60/56	85/71

*H/B; H = hot holding units and B = pot liquor containing green beans.

APPENDIX II

Vitamin B-6 values of individual pot liquor samples

collection date	dining hall	raw	as cooked		1 hr held		2 hr held		3 hr held	
		vitamin B-6								
		mg/100 gm	mg/100 gm	% gain	mg/100 gm	% gain	mg/100 gm	% gain	mg/100 gm	% gain
2-19	C	.021	.030	43	.032	52	.027	29	.027	29
2-24	B	.010	.019	90	.019	90	.018	80	.022	120
3-28	A	.010	.028	180	.022	120	.027	170	.019	90
3-28	B	.010	.018	80	.022	120	.014	40	.018	80
3-28	C	.010	.027	170	.037	270	.029	190	.024	140
4-2	B	.007	.020	186	.020	186	.022	214	.025	257
4-2	C	.024	.023	-4	.020	-17	.026	8	.018	-25
4-7	A	.030	.032	6	.022	-27	.028	-7	.030	0
4-14	A	.021	.026	24	.022	5	.023	10	.023	9

APPENDIX 12

Vitamin B-6 values of individual samples of potatoes

		raw			as cooked					1 hr held				
			vitamin B-6											
			content			content		retention			content		retention	
collection date	dining hall	$\bar{x}$ wt gm	100 gm	serving	$\bar{x}$ wt gm	100 gm	serving	100 gm	serving	$\bar{x}$ wt gm	100 gm	serving	100 gm	serving
			← mg →			← mg →		← % →			← mg →		← % →	
2-24	B	194.5	.320	.620	198.3	.286	.565	91	91	192.1	.250	.480	78	77
2-24	C	191.8	.379	.727	172.5	.360	.621	93	85	193.1	.307	.596	81	82
3-5	A	197.5	.254	.502	202.4	.277	.559	101	111	191.8	.292	.560	115	112
3-5	C	225.9	.226	.511	202.3	.235	.475	110	93	204.8	.169	.345	75	68
3-14	A	219.0	.179	.392	203.3	.149	.304	78	77	207.9	.143	.298	80	76
3-14	B	231.4	.179	.414	213.8	.150	.321	77	78	195.9	.137	.268	77	65
3-14	C	211.6	.300	.634	175.1	.300	.526	99	83	186.0	.282	.524	84	83
4-7	A	183.0	.240	.440	166.6	.279	.463	150	105	145.9	.243	.355	101	76
4-7	B	202.5	.261	.529	190.8	.242	.462	60	87	168.8	.263	.444	101	84

APPENDIX 12 (continued)

Vitamin B-6 values of individual samples of potatoes

collection date	dining hall	2 hr held					3 hr held				
			vitamin B-6								
			content		retention			content		retention	
		$\bar{x}$ wt gm	100 gm	serving	100 gm	serving	$\bar{x}$ wt gm	100 gm	serving	100 gm	serving
			← mg →		← % →			← mg →		← % →	
2-24	B	207.5	.223	.463	70	75	183.6	.194	.356	61	57
2-24	C	185.8	.326	.606	86	83	167.8	.207	.348	55	48
3-5	A	211.6	.252	.533	99	106	192.0	.269	.516	106	103
3-5	C	180.9	.179	.324	79	63	183.1	.182	.334	81	65
3-14	A	189.9	.140	.264	78	67	198.8	.152	.301	85	77
3-14	B	209.6	.154	.312	86	75	202.8	.161	.327	96	79
3-14	C	172.8	.282	.488	94	77	116.4	.374	.435	125	67
4-7	A	148.1	.262	.388	103	88	147.6	.278	.411	116	93
4-7	B	168.0	.262	.441	100	83	177.3	.206	.366	79	69

APPENDIX 13

Vitamin B-6 values of individual samples of peel and flesh from potatoes

collection date	dining hall	raw		as cooked				1 hr held				2 hr held				3 hr held			
		vitamin B-6																	
		100 gm		100 gm		retention		100 gm		retention		100 gm		retention		100 gm		retention	
		flesh	peel	flesh	peel	flesh	peel	flesh	peel	flesh	peel	flesh	peel	flesh	peel	flesh	peel	flesh	peel
		← mg →		← mg →		← % →		← mg →		← % →		← mg →		← % →		← mg →		← % →	
2-24	B	.311	.327	.285	.286	91	87	.271	.231	87	71	.216	.234	69	78	.174	.223	56	68
2-24	C	.399	.356	.372	.346	91	96	.320	.297	86	83	.314	.338	79	94	.199	.220	50	61
3-5	A	.240	.270	.243	.310	101	115	.278	.309	116	114	.224	.288	93	107	.251	.290	105	107
3-5	C	.303	.297	.299	.301	110	90	.320	.234	57	99	.297	.262	55	111	.272	.249	54	119
3-14	A	.215	.135	.168	.132	78	97	.155	.129	72	95	.146	.131	67	97	.166	.132	77	101
3-14	B	.192	.167	.149	.151	77	90	.151	.117	78	76	.151	.147	78	88	.154	.171	80	102
3-14	C	.260	.196	.286	.177	99	101	.148	.195	106	79	.143	.217	98	88	.142	.233	90	84
4-7	A	.204	.284	.307	.249	150	88	.168	.304	82	107	.271	.254	132	89	.258	.299	126	105
4-7	B	.349	.170	.211	.276	60	162	.259	.268	74	157	.263	.262	75	154	.228	.183	65	107

APPENDIX 14

Temperature of hot holding units for potatoes in °C

	dining halls								
	A			B			C		
date	3-5	3-15	4-7	2-24	3-15	4-7	2-24	3-5	3-15
cook/hold group									
as cooked	68	75	75	75	71	68	65	92	74
1 hr held	78	80	76	67	78	70	67	90	74
2 hr held	74	78	74	74	76	65	70	87	68
3 hr held	73	72	76	76	72	72	85	93	68

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