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FOLIC ACID CONTENT OF CHICKEN MEAT PRESSURE-COOKED AND BOILED FROM FROZEN AND THAWED STATE

by

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INTRODUCTION

Folic acid occurs in food in a multiplicity of forms, differing in their biological potency and their stability. The more complex forms of the vitamin occur in foods in greater quantity than the basic form, pteroylmonoglutamic acid (Perloff and Butrum, 1977). Butterworth et al. (1963) found only 5% of the total folacin activity in foods to be pteroylmonoglutamic acid. However, Perloff and Butrum (1977) asserted that different foods contain the different forms of vitamin in varying amounts.

Amounts of folic acid differ from one source of food to another. Legumes are generally good sources of folacin; all dry legumes, except lentils, have more than 100 μg per 100g in the dry state. Cooked or processed legumes are also good sources of folacin. Folacin varies widely among raw vegetables from a low of 12 μg total folacin per 100g in celery to a high of 193 μg in spinach. Fruits contain less than 30 μg total folacin per 100g. Oranges and orange juice, with 46 and 55 μg, respectively, are among the best fruit sources. Raw beef, lamb, pork and poultry muscle all have less than 10 μg total folacin per 100g. However, liver is an excellent source of folacin. Dairy products do not contain high amounts of folacin.

Folates are susceptible to oxidative destruction by heating or other processes. The more finely the food is divided and the longer it is heated (especially in water), the greater the loss of folate. Destruction may be 95% or more of the total folate content. For this

reason, folate deficiency is especially common among people whose diet consists primarily of finely divided foods such as rice and beans (Herbert, 1968). More information about the amounts of this vitamin in foods is still needed.

Most of the publications connected with folic acid and folates are involved with biochemical, clinical, and chemical aspects, and relatively little data are available concerning the more applied topic of food preparation and its effect on the vitamin content. Bender (1978) contends that "the assay of folate has been notoriously inaccurate for many years and assays carried out prior to about 1970, when conditions were made more specific, are unreliable." In addition, little information is available on chicken muscle.

We will compare the content of folic acid in chickens cooked by two different methods (pressure and boiling) and study the effect of cooking from the thawed versus frozen state. Previous studies do not report consistent results in the case of cooking methods and the literature did not address adequately the retention of folic acid in chickens.

REVIEW OF LITERATURE

Dietary Requirements

Folic acid is essential for normal erythrocyte formation and participates as a coenzyme in various chemical reactions (Blakly, 1969). The minimum daily adult requirement for folate is about 50 μg. This requirement is increased by any rise in daily metabolic rate or cell turnover rate, as in hyperthyroidism, pregnancy, and hemolytic

anemia (Herbert, 1968).

The Food and Nutrition Board of the National Research Council established the recommended dietary allowances (RDAs) for folacin at: 400 μg for adults, 800 μg for pregnant women, and 600 μg for lactating women. For children, the folacin RDAs are; 300 μg for ages seven to ten years, 200 μg for ages four to six, 100 μg for ages one to three, and 50 μg for infants. Those allowances are based on total folacin and take into account the fact that not all the pteroylglutamate forms will be absorbed or utilized by the body (Perloff and Butrum, 1977).

Much of the folate present in food is in the polyglutamate forms of pteroylglutamic acid, and although experimental results are conflicting most researchers reported that polyglutamates larger than hepta- or perhaps triglutamate are absorbed poorly (Anonymous, 1974). The enzyme which splits off the glutamate side chains is called folate conjugase; it is present in the intestinal lumen and may be derived from the intestinal epithelium.

Properties of Folic Acid Group Compounds

The basic form is pteroylmonoglutamic acid (PGA), also called folic acid. PGA consists of substituted pteridine, para-amino benzoic acid, and glutamic acid. Additional glutamate moieties attached to the gamma carboxyl group of the glutamic acid yield pteroylpolyglutamic acid. Additional hydrogen atoms, methyl groups, or formyl groups may be attached to PGA to form dihydro, tetrahdro, methyl- or formylfolates.

Pteroylglutamic acid has a molecular weight of 441.42 and is soluble in 100 ml water to the extent of about 1.0 mg at 2°C, 2.5 mg

at 35°C, and 50 to 100 mg at 100°C. The solubility varies at different pH levels. In the range of pH 3 to 4, it is only slightly soluble, but with increasing pH values the solubility increases rapidly.

The stability of pteroylglutamic acid varies with pH. It is more stable in alkaline than in acid solutions (Koser, 1968). Daniel and Kline (1947) found no loss in activity when a stock solution was stored in a refrigerator at 4°C for three months. Biamonte and Schneller (1951) reported that pteroylglutamic acid in an aqueous solution of citrate-phosphate buffer at pH 6 or higher was stable for one year at room temperature, and for eighteen months at 4 to 8°C. However, at pH 5 or lower the solution lost potency rapidly. Decomposition in distilled water at pH 7.0, in M/30 phosphate buffer at pH 7.3, and in sterile culture medium at pH 7.0 held in the dark at 30°C was reported (Koser, 1968).

Pteroylglutamic acid is destroyed during autoclaving (Koser, 1968) and the loss varies with the pH; a 10 μg per ml solution autoclaved at 121°C for 30 min lost 40-45% of its activity at pH 3, and 10-30% activity in the pH ranges of 4 to 12. However, a 1 μg per ml solution in basal medium at pH 6.8 showed no loss in activity on autoclaving at 121°C for 30 min. Dick et al. (1948) noted that on heating there was considerable destruction of pteroylglutamic acid in solutions below pH 4.0 but above pH 5.0, little or no destruction was detected (with S. faecalis) at 100°C for one hour or at 120°C for 15 min.

According to Stokstad et al. (1947) pteroylglutamic acid is inactivated by light. A solution in phosphate buffer at pH 7

exposed in pyrex test tubes to sunlight lost 24% of the biological activity in 1 hr, and 88% in 6 hrs. on exposure to fluorescent light at a distance of 4 ft, the loss was not quite as great; there was no detectable loss in 6 hrs, and a 63% loss in 24 hrs. The destructive effect was not as marked in alkaline solutions of the vitamin. Folate can also be destroyed by sunlight especially in the presence of riboflavin; a 30% loss in one year in tomato juice stored in clear glass bottles compared with only 7% in dark glass has been reported (Bender, 1978). When mixed with certain other B vitamins in solution, there was some decomposition of pteroylglutamic acid (Koser, 1968). In a mixture of 1 mg pteroylglutamic acid and 0.2 mg riboflavin per ml, 85% of the pteroylglutamic acid was destroyed at pH 6.9 in 21 days at 45°C and 94% in 9 months at room temperature (25°C $\pm$ 5°C). In the presence of 1 mg thiamin hydrochloride under the same conditions, the corresponding losses of pteroylglutamic acid were 14 and 46%, respectively. Little or no decomposition occurred in the presence of nicotinamide, pyridoxine, or pantothenyl alcohol, which were present in amounts of 25, 5, and 5 mg per ml, respectively. Stability is not identical for all forms of folic acid in food. The monoglutamate form is moderately heat-stable in acid or neutral solution but tri- and heptaglutamate conjugates are heat unstable.

Folate, as a water-soluble vitamin, can be lost in wet processing and is sensitive to heat. However, if cooking releases available vitamin from the larger polymers then there could be an increase in potency (Bender, 1978).

Soaking of garbanzo beans in water for 12 hrs leached out

5% of its folates; blanching in water at 100°C caused a loss of 20% in 5 min, 25% in 10 min and 45% in 20 min (Bender, 1978). Sterilization in the can at 118°C for 30 min destroyed a further 10%, and since folate is relatively stable at a slightly acid pH, such as existed in the can contents, a longer sterilizing time did not lead to further loss. Hurdle et al. (1968) reported no loss of folate on boiling or frying of chicken or liver, 100% loss on boiling cabbage, 90% loss in spring greens, 70% on boiling and 30% on frying egg yolk.

Methods of Assay

There are a number of assay methods for folic acid: chemical, physical, and microbiological. The latter method is often preferred over the former methods for reasons of economy and convenience. Within the microbiological methods there is a variety of microorganisms that are used for the assay purposes. The two organisms that give the best results and reproducibility, and consequently are used most, are Lactobacillus casei and Streptococcus faecalis (Freed, 1966). The former has the advantage of requiring much lower levels of folic acid for maximum growth and is therefore, more sensitive. L. casei is also the only organism responding well to N^5methyl folates.

Microbiological assay is based on the observation that certain microorganisms require specific vitamins for growth. Using a basal medium complete in all respects except for the vitamin under test, growth responses of the organisms are compared quantitatively in standard and unknown solution.

In his method of assay with L. casei, Freed (1966) uses the hog kidney or chicken pancreas enzymes as conjugases to librate pteroylglutamic acid prior to the assay. The chicken pancreas enzymes, used in this experiment, degrade heptaglutamate to diglutamate. Freed also uses ascorbic acid and phosphate buffer in the original extraction in order to prevent the destruction of heat labile reduced forms of folic acid (Malin, 1975).

Folic Acid Content of Chicken Muscle

The total folic acid of raw chicken was 13.8 - 30.1 μg/100 g, and 30.1 - 50.0 μg/100 g for turkey as determined on a dry weight basis (Hoppner et al., 1972). Toepfer (1951) estimated folic acid in raw chickens to be 13 - 14 μg/100 g and for turkey to be 15 μg/100 g on a dry weight basis using L. casei and without using reducing agents during his assays. Using L. casei, Perloff and Butrum (1977) reported the total folacin in dark meat of chickens was 11 μg/100 g for raw and 7 μg/100 g for cooked and in white meat of chicken, 6 μg/100 g for raw and 4 μg/100 g for cooked. In chicken liver total folacin was 364 μg/100 g for raw tissue and 240 μg/100 g for cooked.

In an earlier investigation (Cheldelin et al., 1943) it was found that total folic acid in dark meat of chickens was 61 μg/41 g for raw and 22 μg/35 g for cooked, and in white meat of chicken, 63 μg/31 g for raw and 21 μg/29 g for cooked. These results are higher than most researchers (Toepfer et al., 1951; Hoppner, 1972; Perloff and Butrum, 1977) have reported, and it may be due to the different method of assay which Cheldelin et al. (1943) used in their study, a method that was

developed at the University of Texas laboratories.

Effects of Precooking Preparations

Freezing. From the sensory and nutritional point of view, freezing is one of the best methods of preserving food. The literature reveals considerable variations in the stability of nutrients in frozen foods because of different processing conditions and the varying extent of inactivation of oxidizing enzymes in the blanching processes. However, there is evidence that reactivation of enzymes can occur; nutritive value of frozen foods can be higher or lower than that of the fresh food, for while blanching removes some nutrients it preserves the remainder by destroying oxidizing enzymes.

Fennema (1975) summarized the literature findings of losses of B vitamins from meat and poultry during freezing and storage; losses varied considerably from 0 to 30 percent for thiamin, riboflavin, niacin, and pyridoxine after 6-12 months at $-18^{o}C$.

Ang et al. (1975) compared the thiamin and riboflavin content of frozen-thawed beef with that of fresh beef. Retention was 93.9 and 94.48% for riboflavin and thiamin, respectively, in the frozen-thawed beef.

Korschevar (1955) reported that raw calf liver lost an average of 27 and 34%, respectively, of its thiamin and riboflavin during sixty days' frozen storage, but the measurable niacin increased 10%. In another experiment, under the same conditions, Kotschevar (1955), found that losses in all three vitamins occurred as follows: thiamin, 15%; riboflavin, 13%; and niacin, 1%.

Thawing. Thawing or defrosting is another factor that causes losses of nutrients from foods. Singh and Essary (1971 a,b) reported significant effects of thawing method on drainage from broilers. Four methods of thawing were compared: room temperature at 26-28°C for 6 hrs, cold water at 21-22°C for 3.5 hrs, refrigeration at 3-5°C for 36 hrs, and warm water at 44-46°C for 1.5 hrs. They found greater loss of nutrients with the longer thawing time; while faster thawing reduced the amount of drainage and the loss of solids, proteins, and vitamins. They also reported higher losses of riboflavin in the drainage fluid of the refrigerated and room temperature thawed birds compared with the two other methods. Khan and Lentz (1965) evaluated the volume and composition of drainage during thawing, and found substantial concentrations of ribose and protein. During thawing there was a loss in the juices of about 10% of the water-soluble B vitamins, and similar losses occur in thawing frozen fish. Kotschevar (1955) found losses during thawing of raw frozen calves' liver after sixty days storage were: thiamin, 6%; riboflavin, 10%, and niacin, 10%.

Obvious advantages of cooking meat from the frozen state include eliminating the time and bother of thawing, reducing nutritional losses, and eliminating the possibility of spoilage due to improper thawing. Some inconveniences associated with cooking from the frozen state are increased cooking times and greater energy consumption. A significant amount of nutrients may be lost in the drip of thawed chicken. Cooking from the frozen state may reduce this loss as no thaw drip would occur.

It has been found that turkey cooked from the frozen or partially frozen state retained more vitamin B_6 than turkey cooked from the thawed state (Engler and Bowers, 1975). Also liver cooked from the frozen

state retained significantly more thiamin, riboflavin, and niacin than liver cooked after thawing (Kotschevar, 1955).

Effects of Cooking on Nutrients

Different methods of cooking have resulted in different retention percentages for the various vitamins (Demby, 1979). Kotschevar (1955) found that losses due to cooking calf liver were; thiamin, 20% and niacin,15% when cooked from the frozen state. Additional losses were: thiamin, 3% and niacin, 15% when cooked from the frozen and thawed state. Cooking time was 6 min for cooking from the frozen state and 5 min for cooking from the thawed state.

Cheldelin et al. (1943) concluded that "of all the vitamin studied, folic acid showed the greatest losses due to cooking. With the exception of liver and sauerkraut, which retained the bulk of their folic acid content, losses among meats range from 46% in halibut to 95% in pork chops; losses in vegetables ranged from 69% in cauliflower to 97% in carrots." Chicken meat fried in an open pan lost 64% of its folic acid in the dark meat and 67% of the folic acid in the white meat.

It is often assumed that pressure cooking has an advantage over boiling since the heating time is shorter and less of the soluble nutrients should be leached out. However, some of the reported results are conflicting and there are marked differences between the nutrients. Munsell et al. (1949) showed smaller losses of vitamins from cabbage cooked under pressure than with boiling; namely, 33% loss of vitamin C compared with 70%, 12% loss of thiamin compared with 55%, and zero for

riboflavin compared with 50%. The principal cause of loss is by leaching rather than heat.

Krehl and Winters (1950) compared the loss of four vitamins and two minerals from a variety of vegetables cooked: (a) under pressure with 125 ml water, (b) in an open pan with a minimum of water, and (c) in an open pan with 125 ml of water. With the same volume of water there was little difference between open pan and pressure cooking, despite the difference in times. The greatest loss occurred with the larger volumes of water and losses were least with "waterless cooking."

Trefether et al. (1951) found virtually no difference between open pan boiling for 13 min, and pressure cooking at 5 lb for 7 min, 10 lb for 6 min, and 15 lb for 5.5 min for ascorbic acid, thiamin, and riboflavin in a variety of foods. Noble (1967) showed a clear advantage for pressure cooking in retention of vitamin C in a variety of vegetables. More recently, it has been shown that with several vegetables that pressure cooking with a loss of 25 - 50% of thiamin was better than steaming with 50% loss, and much better than boiling with 75 - 80% loss. For vitamin C, the results depended on the vegetable; amaranth leaves lost 80% under pressure and 70% on steaming; French beans lost nothing when cooked in an open pan with a minimum of water, and 30% both on steaming and under pressure. Drumstick leaves lost 50%, 30% and 25%, respectively, by these three methods (Kamalanathan et al., 1972).

No general conclusion can be drawn about the relative value of pressure cooking as such since so many factors from type of food to volumes of water must be taken into account. Therefore, there is need to compare the effect of two methods of cooking (pressure and

boiling) on the content of folic acid in the chickens.

EXPERIMENTAL PROCEDURE

Samples and Treatments

Sixteen dressed baking hens, 4-6 lbs each, were purchased from a local market. After necks and giblets were removed, hens were packaged in plastic bags, wrapped in aluminum foil, frozen, and stored at -18°C for 12 to 15 weeks. Hens were assigned randomly to the four treatments: 1) pressure-cooked from frozen state, 2) pressure-cooked from thawed state, 3) boiled from frozen state, and 4) boiled from thawed state.

For each of the four weekly evaluation periods, two hens were thawed 72 hrs at 4°C immediately before cooking and two were cooked from the frozen state. For boiling, chickens were placed in 9.36ℓ of tap water. After the temperature reached 100°C, frozen hens were boiled for 2 hrs and 10 min and thawed hens were boiled for one hr and 50 min. For pressure cooking, chickens were placed in 1.1ℓ of tap water. The pressure was stabilized at 10 lbs and frozen chickens were cooked for 45 min and thawed chickens for 35 min.

Weights were taken before and after cooking to determine cooking losses. Skin and surface fat were removed and the breast (pectoralis major) muscle and a composite of the thigh muscles were ground twice and assayed for folic acid, fat, and moisture content.

Determination of Folic Acid, Moisture and Fat

Folic acid was determined for duplicate 1g samples of dark and light meat (Freed, 1966). Samples were incubated with conjugase to liberate pteroylglutamic acid. Difco Bacto-Lactobacilli broth AOAC (code 0901-15) and Bacto-Lactobacilli agar AOAC (code 0900-15) were used for culture media. Difco-Folic Acid casei medium (code 0822-15) was used for assay media. Samples were boiled in 10 ml of phosphorus buffer with ascorbic acid (Difco Bacto-Folic Buffer A, Code 3246-21) for 5 min and cooled. Folic acid content was calculated from a standard growth curve. Percentages of moisture and fat were determined by AOAC procedures (AOAC, 1975).

Analysis of Data

Data were submitted to analysis of variance; the main effects as well as the interaction were studied. When F-values were significant, LSD's were calculated at the 5% level.

Source	df
Method (M)	1
State (S)	1
MxS	1
Replication (Rep)	3
Error	9
Total	15

RESULTS AND DISCUSSION

Hens were assigned randomly to treatments. Their average initial weights ranged from 2026 to 2441g before cooking (Table 2, Appendix). Analysis of variance indicated no significant differences between the treatments for initial weights (Table 3, Appendix).

Cooking losses were not different from one cooking condition to the other or from one replication to the other (Table 1 and Table 5, Appendix). These results are in agreement with other findings. Yingst et al. (1971) found that cooking method did not significantly influence the yield of cooked broilers. Molonon et al. (1980) obtained total losses from turkey roasted and braised in the range of 30.2 to 41%; such losses are comparable to those obtained in this experiment.

Mean values of 4 replications for folic acid, moisture, and fat content of hens and cooking losses are reported in Table 1. Data for individual replications and statistical analysis are in the Appendix (Tables 5, 6, 7, 8).

Effects of State on Folic Acid Content

Breast meat from hens cooked from the frozen state contained more ($P < 0.0001$) folic acid than breast meat from hens cooked from the thawed state. Frozen-boiled and thawed-boiled thigh muscle contained similar amounts of folic acid. But the forzen-pressured cooked thigh muscle had more ($P < 0.0001$) folic acid than the thawed-pressured cooked thigh muscle.

Generally, frozen and pressured meat yielded the highest amount of folic acid and the thawed, boiled meat contained the least amounts of

Table 1 - Mean[a] values of cooking losses and folic acid, moisture, and fat content of chicken meat.

	Thawed		Frozen		LSD*	Sign. of F-value			
	Boiled	Pressured	Boiled	Pressured		S[b]	M[c]	SxM	Rep[d]
Cooking loss, %	30.00	29.00	29.00	28.00		ns	ns	ns	ns
Folic acid µg/100g muscle									
breast	8.663	8.638	11.300	15.268	1.322	***	**	**	ns
thigh	11.648	13.325	12.400	20.500	0.992	***	***	***	ns
Folic acid µg/1g moisture and fat-free muscle									
breast	0.273	0.270	0.350	0.503	0.054	***	**	**	ns
thigh	0.381	0.423	0.406	0.669	0.034	***	***	***	*
Moisture, %									
breast	66.000	64.843	65.568	67.575	0.981	ns	ns	*	ns
thigh	64.180	63.678	64.363	65.085	---	ns	ns	ns	*
Ether extract, %									
breast	2.188	2.998	2.060	1.963	---	ns	ns	ns	ns
thigh	5.195	4.745	5.008	4.053	---	ns	ns	ns	ns

a - Mean of four replications
b - State of bird (frozen or thawed)
c - Method of cooking (boiling or pressure
d - Replications
* - significant at 5%
** - significant at 0.1%
*** - significant at 0.01%
ns - not significant

folic acid. These results favor cooking from the frozen state over the thawed state and are in agreement with the work of Kotschevar (1955) on the effect of freezing and thawing on nutrients. Khan and Lentz (1965) found that during thawing there was a substantial amount of ribose and protein in the drainage. Surveying the literature, Engler and Bowers (1976) concluded that, though stable to most thawing conditions, thiamin, riboflavin, niacin, pyridoxine, pantothenic acid and folic acid do transfer to the drip during thawing. Cooking meat from the frozen state may help to conserve some vitamins.

Effects of Cooking Method on Folic Acid Content

Pressure-cooked, frozen breast and thigh muscle had higher ($P \leq 0.001$) amounts of folic acid than boiled frozen breast and thigh muscle. Also, pressure-cooked, thawed thigh muscle had more ($P \leq 0.005$) folic acid than boiled, thawed thigh muscle. But, pressure-cooked, thawed breast muscle and boiled thawed breast muscle had similar amounts of folic acid.

These results generally favor the pressure cooking method over boiling for hens. This could be explained by the fact that a larger amount of water is used in boiling than in pressure-cooking, and may cause greater amounts of folic acid to escape in the drip. In addition, boiling takes longer periods of time. Such findings confirm results concerning the advantageous use of pressure-cooking over boiling in the retention of vitamins (Noble, 1967; Munsell, et al., 1949; Krehl and Winters, 1950; Bender, 1978).

Folic acid content of dark meat was more than that of light meat ($P<0.005$) throughout all the four experimental cooking conditions, thus confirming previous work in the field (Perloff and Butrum, 1977).

Moisture and Fat Content

Moisture content of frozen, pressure-cooked breast muscle was greater ($P<0.05$) than that of breast muscle of the other three treatments, which did not differ significantly from each other (Table 1). Frozen, pressure-cooked hens also had the lowest cooking losses which may explain the higher moisture content. Amount of fat was not affected by cooking method or cooking from frozen or thawed state.

SUMMARY

Sixteen hens, 8 frozen and 8 thawed, were cooked by boiling or pressure-cooking. Folic acid, cooking loss, fat, and moisture content were determined. No significant difference among cooking losses for the hens prepared by the four treatments were found.

Moisture content of frozen, pressure-cooked breast muscle was greater than that of the other three treatments. The amount of fat was not affected by cooking method or cooking from frozen or thawed state.

Generally, muscles from hens cooked from the frozen state contained more folic acid than those cooked from the frozen-thawed state. Pressure-cooked meat contained more folic acid than boiled meat. Thigh muscle contained more folic acid than did breast muscle.

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APPENDIX

Table 2 - Initial weights (in grams) of 16 hens assigned randomly to four replications.

	Rep 1	Rep 2	Rep 3	Rep 4
Frozen-boiled	1886	2219	1974	2024
Frozen-pressured	2090	2843	2522	2307
Thawed-boiled	2268	2471	2101	2181
Thawed-pressured	2088	1967	2738	2222

Table 3 - Two-way analysis of variance for the distribution of the initial weights of the chickens to four experimental cooking treatments and four replications.

Source of Variance	SS	df	MS	F-values
Between replications	219188.69	3	73062.897	1.152 ns
Between treatments	345867.19	3	115289.063	1.817 ns
Error	570911.93	9	63434.658	
Total	1135967.805	15		

Table 4 - Weights (in grams) for 16 cooked hens assigned on four replications.

Condition	Rep 1	Rep 2	Rep 3	Rep 4
Frozen-boiled	1339	1575	1411	1437
Frozen-pressured	1505	2047	1816	1661
Thawed-boiled	1588	1730	1471	1527
Thawed-pressured	1482	1397	1944	1578

Table 5 - Two-way analysis of variance for the effect of cooking methods and replications on the amount of loss in chickens' weight.

Source of variance	SS	df	MS	F-value
Cooking methods	27723.69	3	9241.23	3.028 ns
Replications	34387.69	3	11462.56	3.756 ns
Error	27466.56	9	4051.84	
Total	89577.94	15		

Table 6 - Values (μg/100g) for folic acid content of chicken muscle.

State	Method	
	Pressure-cooked	Boiled
Frozen		
Breast muscle	15.08	11.35
	16.16	10.50
	14.20	12.20
	15.63	11.16
Thigh muscle	21.70	12.75
	19.16	12.18
	21.20	12.37
	20.25	12.30
Thawed		
Breast muscle	8.19	8.865
	8.20	8.990
	8.04	8.760
	10.12	8.040
Thigh muscle	13.25	11.625
	13.50	11.750
	12.80	11.250
	13.75	11.970

Table 7 - Values (μg/1g) for folic acid content of chicken muscle, moisture- and fat-free.

State	Method	
	Pressure-cooked	Boiled
Frozen		
Breast muscle	0.528	0.364
	0.502	0.308
	0.441	0.364
	0.541	0.363
Thigh muscle	0.731	0.430
	0.597	0.379
	0.668	0.391
	0.678	0.422
Thawed		
Breast muscle	0.249	0.288
	0.243	0.271
	0.247	0.283
	0.342	0.249
Thigh muscle	0.435	0.380
	0.395	0.369
	0.429	0.374
	0.432	0.399

Table 8 - Analysis of variance for the effect of state (thawed vs. frozen), methods of cooking (boiling vs. pressure), interaction of state and cooking methods, and replications on folic acid content of chicken meat.

Source of variation	Mean Squares				Error mean squares	F-values			
	State	Cooking method	Interaction (SxM)	Replications		State	Method	Interaction	Replications
Folic acid (before excluding fat and moisture)									
Breast muscle	85.933	15.524	15.92	0.442	0.736	116.780	21.100	21.640	0.200
Thigh muscle	64.080	97.121	42.25	0.984	0.414	154.73	234.520	102.020	0.790
Folic acid (after excluding fat and moisture)									
Breast muscle	0.096	0.023	0.024	0.005	0.001	77.950	18.460	19.710	1.340
Thigh muscle	0.073	0.093	0.049	0.008	0.001	145.700	185.200	96.860	5.250
Moisture									
Breast muscle	5.290	0.723	10.017	10.588	1.620	3.260	0.450	6.180	2.180
Thigh muscle	2.528	0.048	1.501	25.729	2.277	1.110	0.020	0.660	3.770
Fat									
Breast muscle	1.351	0.508	0.824	2.261	1.235	1.090	0.410	0.670	0.610
Thigh muscle	0.774	1.974	0.255	1.784	1.695	0.460	1.160	0.150	0.350

Folic Acid Content of Chicken Meat Pressure-Cooked and Boiled From Frozen and Thawed State

by

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

Sixteen hens, 8 frozen and 8 thawed, were cooked by boiling or pressure-cooking. Cooking loss and folic acid, moisture, and fat content were determined. For folic acid assay, duplicate 1g samples incubated with conjugase to liberate pteroylglutamic acid were used. Growth response of Lactobacillus casei was measured and folic acid content was calculated from a standard growth curve. Moisture and fat were determined using AOAC methods. Data were subjected to analysis of variance.

No significant differences among cooking losses for the hens prepared by the four treatments were found. Moisture content of frozen, pressure-cooked breast muscle was greater than that of the other treatments. The amount of fat was not affected by cooking method or by cooking from the frozen or thawed state. Generally, muscles from hens cooked from the frozen state contained more folic acid than those cooked from the frozen-thawed state. Pressure cooked meat contained more folic acid than boiled. Thigh muscle contained more folic acid than did breast muscle.