VIII

ЕВРОПЕЙСКИЙ КОНГРЕСС РАБОТНИКОВ НАУЧНО-ИССЛЕДОВАТЕЛЬСКИХ ИНСТИТУТОВ МЯСНОЙ ПРОМЫШЛЕННОСТИ

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RELATION BETWEEN QUALITY AND BIOCHEMICAL CHANGES IN POULTRY MEAT DURING STORAGE AT ABOVE-FREEZING TEMPERATURES

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RELATION BETWEEN QUALITY AND BIOCHEMICAL CHANGES IN POULTRY MEAT DURING STORAGE AT ABOVE-FREEZING TEMPERATURES

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EXPERIMENTAL

Breast and leg meat were obtained from one flock of chickens raised under comparable conditions and slaughtered in the laboratory. The chickens were killed by cutting the jugular vein and carotid arteries, bled for 2-3 minutes, scalded for 2 minutes at 53-54°C, plucked by hand, eviscerated, and aged for 18-20 hours in drained ice. For taste panel analyses, legs and breasts were removed from the carcasses after ageing and dipped first in an aqueous chlortetracycline solution (10 parts per million) and then in an aqueous sodium hypochlorite solution (50 ppm available chlorine). Each treatment lasted 10 seconds. These pieces were rinsed with sterilized distilled water and stored in a nitrogen atmosphere in sterilized parchment-paper lined metal cans. For the biochemical analyses, deboned meat samples were treated similarly, except that they were stored individually in nitrogen in sterile plastic bags. Bacterial counts made on all samples showed that aseptic conditions were maintained during storage.

Meat for taste panel analyses was deboned and heated in evacuated and sealed plastic bags at the rate of 30-40°C per hour until the temperature of the center of the meat was 90°C. The meat was weighed before and after cooking to obtain the weight loss. The liquid collected in the bag during cooking was analysed to determine losses of minerals and lactate. The cooked meat was cut into 5-10 gr. samples excluding tendons and connective tissue. A 2-4 mm layer of meat originally

situated next to the skin was also discarded because its tenderness might have been affected by the scalding used to facilitate feather removal. Samples were served in covered dishes.

The taste panel consisted of nine people, and pair comparison was used in all tests. One of the coded samples was from meat stored at 0°C (test), the other sample (control) was from chickens frozen and stored at -40°C at the beginning of the storage period and thawed overnight at +5°C before use. Each panel member was asked to indicate whether or not differences in odor or flavor existed between the samples and which, if either, of the two samples was more tender or more juicy than the other. Each test was repeated three times at a single sitting of the panel to give a total of 27 judgments for each comparison of test and control samples. Binomial distribution tables were used to assess the statistical significance of the results (6,16).

For the determination of loss of minerals and lactic acid during cooking, a measured sample of the liquid collected from the meat after cooking was mixed with trichloroacetic acid (final concentration 15%) and kept at 2-5°C overnight before filtering. The filtrate was analysed for its sodium, potassium, calcium, magnesium, phosphate, chloride, and lactic acid contents. Sodium and potassium were determined by flame photometry, chloride according to Kolthoff and Sandell (10), phosphate according to Polley (15), calcium and magnesium by the methods of Marier and Boulet (11,12), and lactic acid by the method of Barker and Summerson (2). Losses were calculated in gm/100 gr.meat.

in Figs. 1 and 2. Odor and flavor of breast and leg meat held at 0°C became significantly different from that of control samples after 4 weeks of storage. Several panel members noted that odor and flavor decreased in intensity during the first 4 weeks of storage. Some panel members noted that odor and flavor of 5-week-old test samples, although different from the control, were not objectionable. With raw meat, off-odors were noticeable about 1-2 weeks earlier than with cooked meat.

The effect of storage at 0°C on tenderness and juiciness differed in breast and in leg meat. The control sample of breast meat was usually rated more tender than the test sample, although equally juicy. With leg meat, however, the control sample was rated less tender and juicy than the test sample in most instances. This indicates that appreciable tenderization occurred in the leg meat after the initial 24 hours of ageing. This tenderizing process may have masked opposing changes in tenderness and juiciness during storage. The variation in tenderness and juiciness between birds and between samples from the same bird was relatively large.

It should be pointed out that off-odor and off-flavor were probably noticed earlier under the test conditions than they would be ordinarily. Under practical conditions, methods of packaging, cooking, seasoning, and serving, would tend to reduce and mask off-odor and off-flavor.

Biochemical analysis

The results presented in Figs. 3 and 4 show that extensive proteolysis occurred in both breast and leg meat

during storage at 0°C. The increase in non-protein nitrogen (Fig. 3) was approximately equal to the increase in free amino-acid nitrogen as determined by the ninhydrin method. The rapid increase in the amount of phospho-18-tungstic-acid-positive materials during storage (Fig. 4) indicated that substances other than amino acids were also formed in appreciable quantities as a result of proteolysis.

Storage at 0°C affected the extractability of nitrogenous material in leg meat, but not in breast meat. About 53% of the nitrogenous material in leg meat could be extracted 24 hours after slaughter, while 78% (±2%) could be extracted between one and five weeks of storage. In breast meat, on the other hand, 88% (±3%) of the nitrogenous material could be extracted regardless of storage time. The results with leg meat indicate that the protein extractability increased during post-rigor tenderization, as has been observed for breast meat (19).

Loss of weight and salts during cooking

Weight losses in the control samples of breast meat were appreciably smaller than in samples of breast meat stored for one week, but weight loss did not increase appreciably thereafter (Fig. 5). In leg meat, differences in weight loss between control and test samples were small (Fig. 6). After 4 weeks of storage, the amount of fluid exuded during storage ("drip") increased markedly and, as a result, losses during cooking were reduced.

Storage time markedly affected the loss of some salts from breast and leg meat during cooking (Figs. 5 and 6).

The amounts of sodium, calcium, and chloride lost increased appreciably with storage time and at a greater rate than total weight loss. Losses of magnesium and phosphate in breast and leg meat did not change appreciably with storage, while losses of potassium and lactic acid decreased slightly in leg meat, but not in breast meat.

DISCUSSION

The storage life of chicken meat under the test conditions (4-5 weeks) was more than twice the storage life obtainable under good commercial conditions. Odor and flavor changes limited storage life, and since microbial activity was excluded, biochemical changes must have caused the off-odors and off-flavors that developed. In breast meat, changes in tenderness ran closely parallel to odor and flavor changes and were probably related to loss of weight during cooking. In leg meat, the post-rigor tenderizing process made it impossible under the test conditions to detect further changes in tenderness and juiciness during storage.

Analysis of the non-protein nitrogen fraction in breast and leg meat showed that the rate of proteolysis in poultry meat during storage is rapid and that relatively large amounts of amino acids and peptides containing sulfhydryl groups and their breakdown products are formed. These compounds are known to affect odor and flavor (3,7). It is also known that initial proteolytic changes are largely confined to alterations in the structure of proteins (5,13,14,18). This may explain why the water- and ion-binding properties of

the meat proteins are markedly affected during the first week of storage. The role of proteolysis in quality deterioration of poultry meat is being investigated further.

Although detailed comparisons of quality deterioration and biochemical changes occurring during storage at above-freezing temperatures with those occurring during frozen storage must await further study, an indication of the relation can be obtained using some of the results obtained by Klose et al (9). They determined at what time odor changes in raw meat of cut-up fryers were noticeable during storage at -7 to -20°C in nitrogen. Their results and results obtained during storage at 5°C, in addition to those obtained during storage at 0°C, are plotted in Fig. 7. Taken together, the work of Klose et al (9) and the results presented in this paper indicate that the temperature coefficient of odor-changing reactions is approximately constant between +5 and -20°C and hence ice formation per se does not appear to affect significantly the rate of odor deterioration, although it may affect the type of off-odor developed.

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SUMMARY

The relation between changes in quality (odor, flavor, tenderness, and juiciness) and biochemical changes in muscle proteins (extractable nitrogenous material, proteolysis, water- and ion-binding properties) of poultry breast and leg meat, stored aseptically in nitrogen at 0°C, was studied. Odor and flavor of stored meat, as rated by a taste panel, became significantly different from odor and flavor of fresh meat after four to five weeks of storage. Stored breast meat was rated less tender than fresh breast meat, although equally juicy. Stored leg meat, on the other hand, was found more tender and juicy than fresh leg meat, indicating that appreciable tenderization occurred during the first week of storage. In breast meat, the amount of extractable nitrogenous material was not affected during storage; in leg meat, it increased markedly during the first week of storage (tenderization). Proteolysis in breast and leg meat during storage was appreciable, resulting in the formation of free amino acids and substances containing sulfhydryl groups. The ion-binding properties of breast and leg meat, as measured by loss of weight and minerals during cooking, decreased markedly during storage. The water-binding properties of breast meat decreased appreciably during the first week of storage, while that of leg meat did not change significantly with storage time. The relation between these changes and changes in quality is discussed.

REFERENCES

1. A.O.A.C. Official and tentative methods of analysis of the Association of Official Agricultural Chemists, 8th ed. Washington (1955).

2. Barker, S.B. and Summerson, W.H. The colorimetric determination of lactic acid in biological material. J. Biol. Chem. 138, 535 (1941).

3. Bender, A.E. and Ballance, P.E. A preliminary examination of the flavor of meat extract. J. Sci. Food Agr. 12, 683 (1961).

4. Bradley, H.C. and Bailey, B.E. Estimation of decomposition of fish muscle. Food Res. 5, 487 (1940).

5. Gregely, J., Gouvea, M.A. and Kariman, D. Fragmentation of myosin by chymotrypsin. J.Biol.Chem. 212, 165 (1955).

6. Gridgeman, N.T. Pair comparison, with and without ties. Biometrics 15, 382 (1959).

7. Hawk, P.B., Oser, B.L. and Summerson, W.H. Practical physiological chemistry, 13th ed. McGraw-Hill Book Co. (1954).

8. Khan, A.W. (In preparation).

9. Klose, A.A., Pool, M.F., Campbell, A.A., and Hanson, H.L. Time-temperature tolerance of frozen foods. XIX. Ready-to-cook cut-up chicken. Food Tech. 13, 477 (1959).

10. Kolchoff, I.M. and Sandell, E.B. Textbook of quantitative inorganic analysis, 3rd ed. The MacMillan Co., New York (1956).

11. Marier, J.R. and Boulet, M.A. Direct microdetermination of calcium in milk. Agr. Food Chem. 4, 720 (1956).

12. Marier, J.R. and Boulet, M.A. Turbidimetric microdetermination of magnesium in milk. J. Dairy Sci. 42, 981 (1959).

13. Mihalyi, E. and Szent-Gyorgyi, A.G. Trypsin digestion of muscle proteins. I. Ultracentrifuge analysis of the process. J. Biol. Chem. 201, 189 (1953).

14. Neurath, H. and Bailey, K. The proteins, vol. II, part B. Academic Press, New York (1954).

15. Polley, J.R. The micro-colorimetric determination of inorganic phosphate in plasma and urine. Can. J. Res. E27, 265,(1949).

16. Roessler, E.B., Baker, G.A. and Amerine, M.A. One-tailed and two-tailed inorganoleptic comparisons. Food Res. 21, 117 (1956).

17. Rosen, H. A modified ninhydrin colorimetric analysis for amino acids. Arch. Biochem. Biophys. 67, 10 (1957).

18. Szent-Gyorgyi, A.G. Chemical physiology of contraction in body and heart muscle. Academic Press, New York (1953).

19. Weinberg, B. and Rose, D. Changes in protein extractability during post-rigor tenderization of chicken breast muscle. Food Tech. 14, 376 (1960).

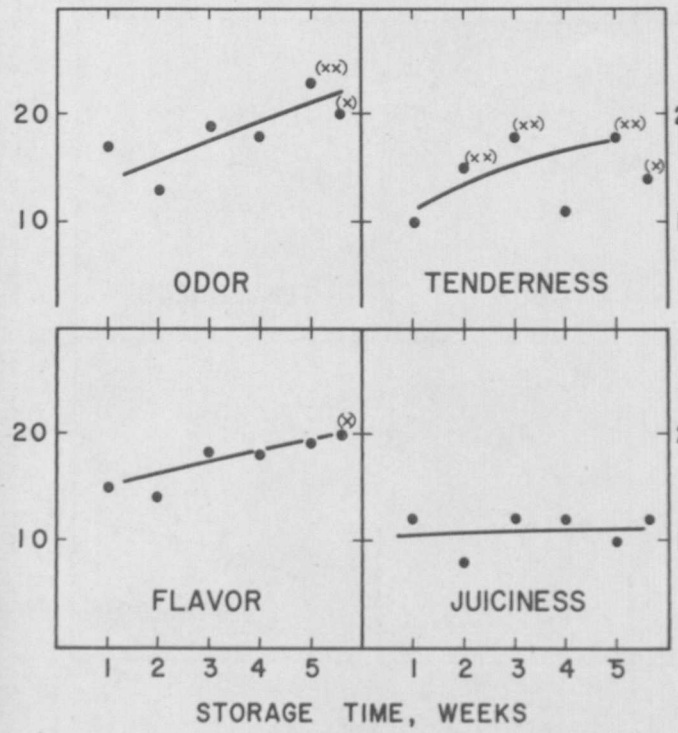

FIG. 1. TASTE PANEL COMPARISON OF CHICKEN BREAST MEAT STORED AT 0°C (TEST) AND −40°C (CONTROL).

NOTES :- 1. ALL SAMPLES FROM COMPARABLE 10-WEEK OLD CHICKENS.
2. EACH COMPARISON CONSISTED OF 27 JUDGMENTS.
3. X INDICATES SIGNIFICANT DIFFERENCE AT 5% LEVEL.
XX INDICATES SIGNIFICANT DIFFERENCE AT 1%LEVEL.

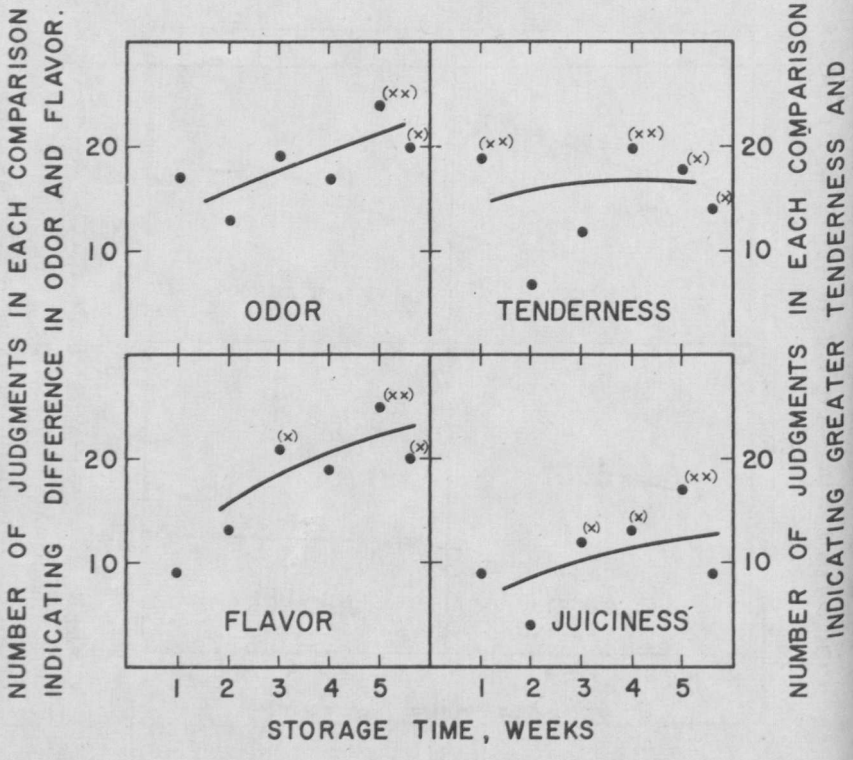

FIG. 2. TASTE PANEL COMPARISON OF CHICKEN LEG MEAT STORED AT 0°C (TEST) AND −40°C (CONTROL).

NOTES:- 1. ALL SAMPLES FROM COMPARABLE 10-WEEK OLD CHICKENS.
2. EACH COMPARISON CONSISTED OF 27 JUDGMENTS.
3. X INDICATES SIGNIFICANT DIFFERENCE AT 5% LEVEL. XX INDICATES SIGNIFICANT DIFFERENCE AT 1% LEVEL.

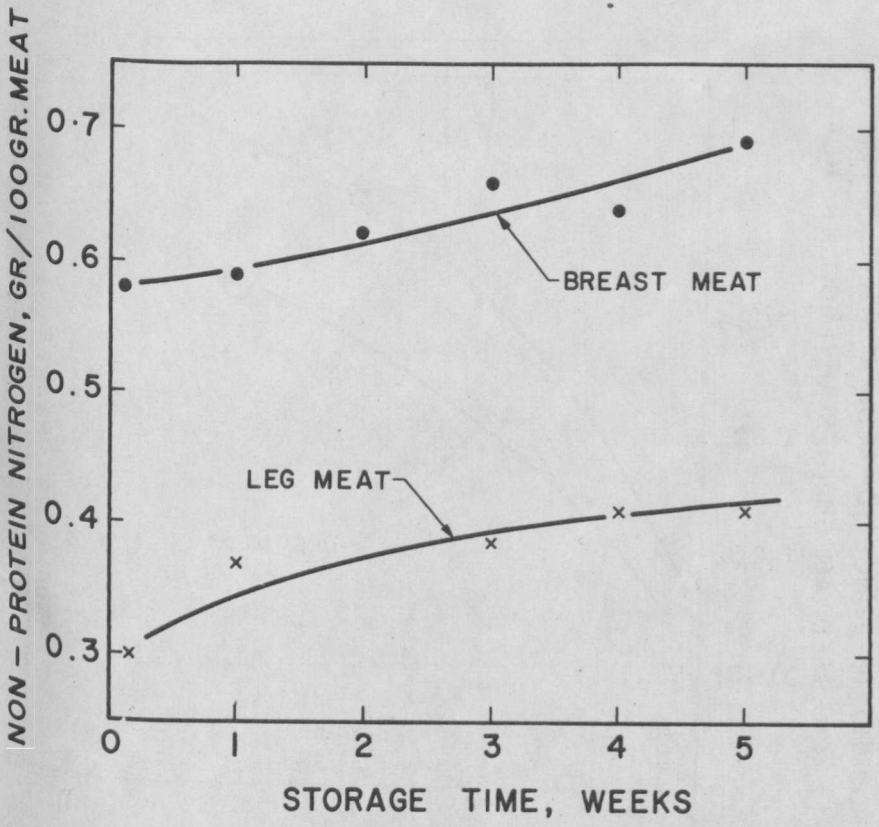

FIG.3 INCREASE OF NON-PROTEIN NITROGEN IN BREAST AND LEG MEAT OF 10-WEEK OLD CHICKENS DURING STORAGE AT 0°C.

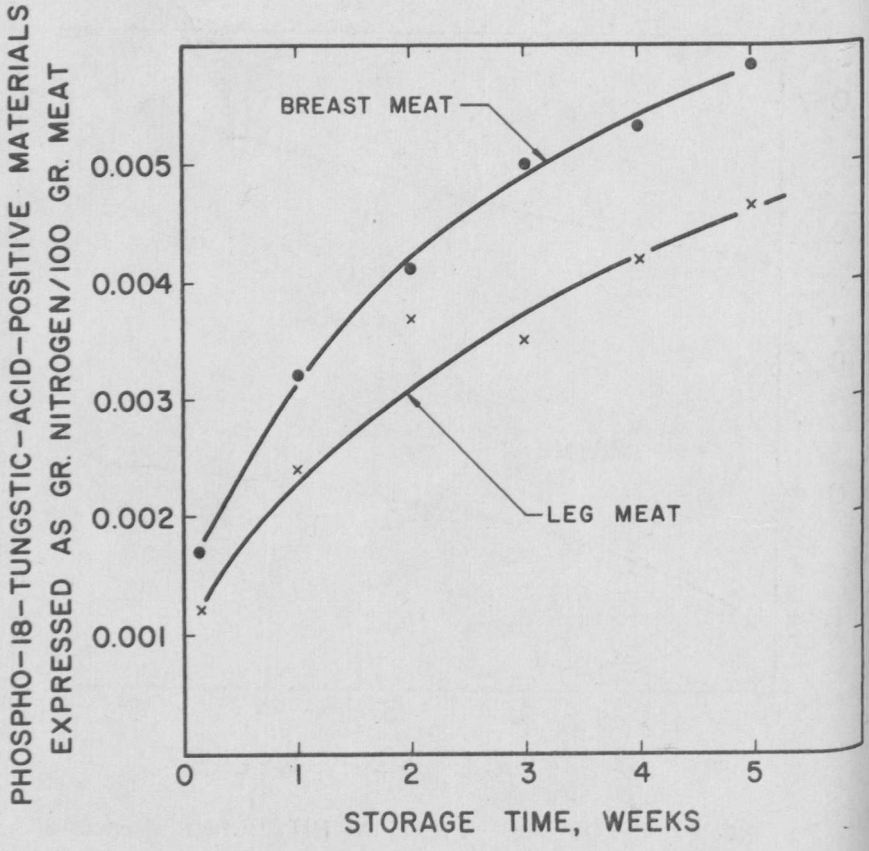

FIG. 4 INCREASE OF PHOSPHO-18-TUNGSTIC-ACID POSITIVE MATERIALS IN BREAST AND LEG MEAT OF 10-WEEK OLD CHICKENS DURING STORAGE AT 0°C.

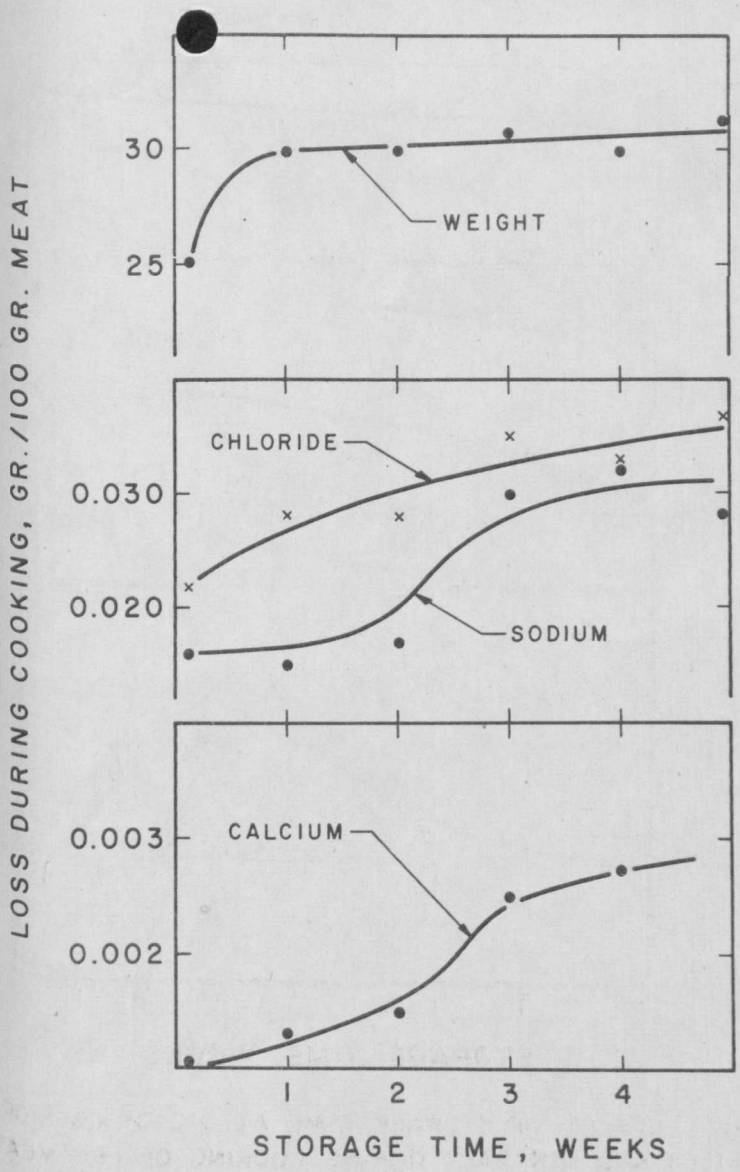

FIG. 5 EFFECT OF STORAGE TIME AT 0°C ON LOSS OF WEIGHT AND MINERALS DURING COOKING OF BREAST MEAT OF 10-WEEK OLD CHICKENS.

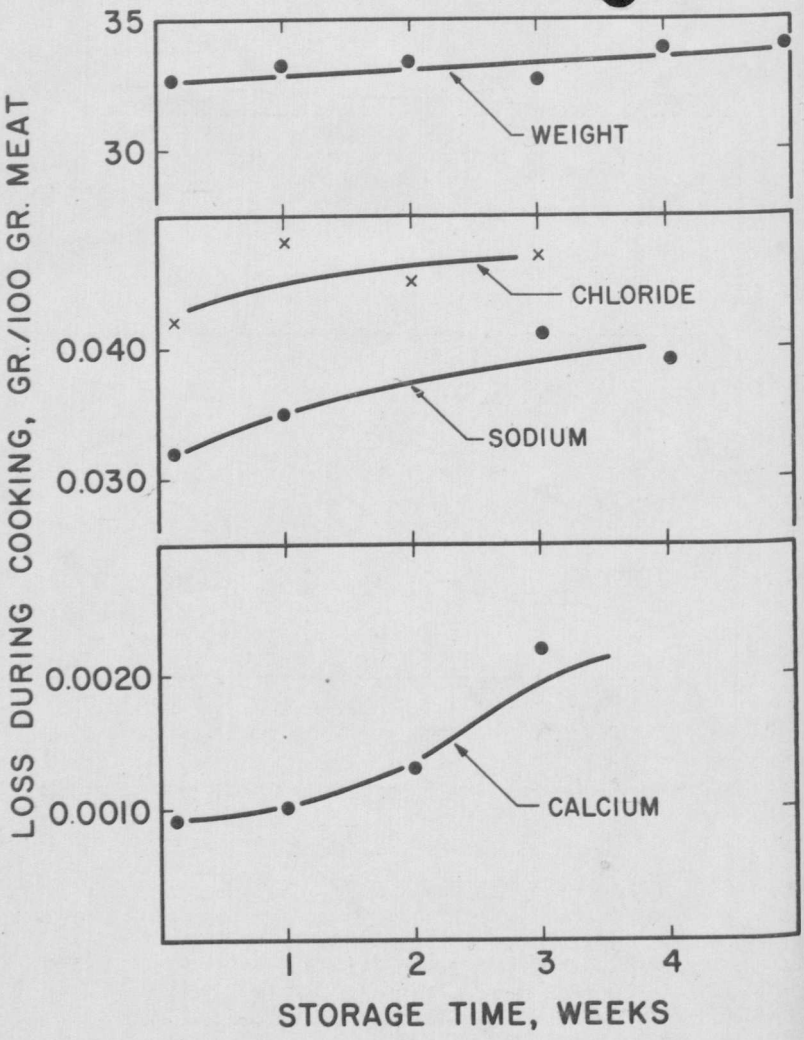

FIG. 6 EFFECT OF STORAGE TIME AT 0°C ON LOSS OF WEIGHT AND MINERALS DURING COOKING OF LEG MEAT FROM 10-WEEK OLD CHICKENS.

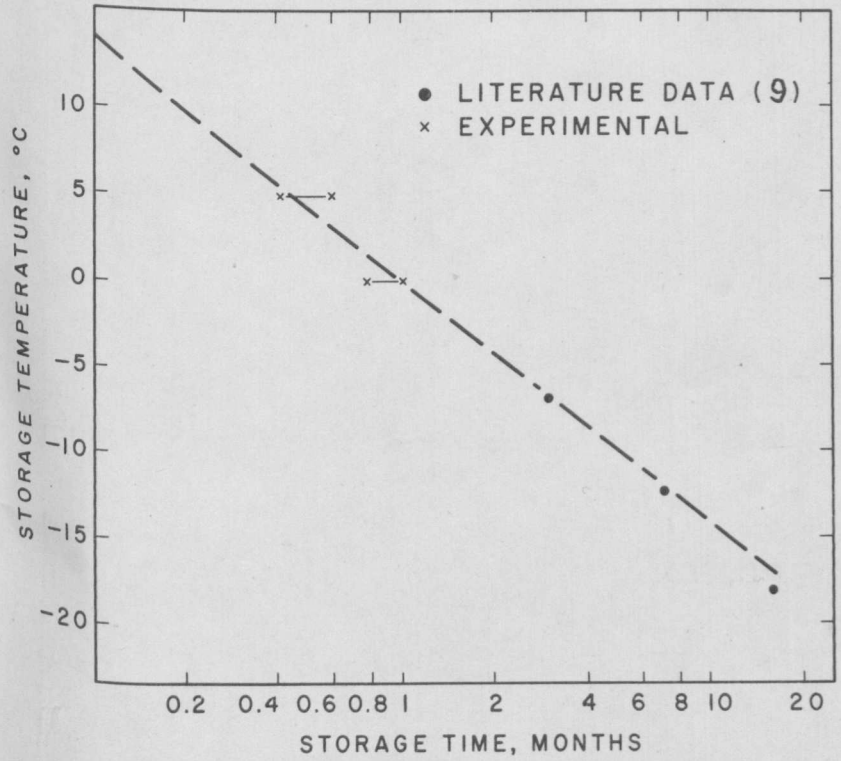

FIG. 7. RELATION BETWEEN THE INITIAL DEVELOPMENT OF OFF—ODORS IN RAW CHICKEN MEAT AND STORAGE TIME AND TEMPERATURE (EXPERIMENTAL RESULTS ARE FOR BREAST AND LEG MEAT FROM 10—WEEK OLD CHICKENS, STORED IN NITROGEN UNDER ASEPTIC CONDITIONS AT ABOVE—FREEZING TEMPERATURES. LITERATURE RESULTS ARE FOR SIMILAR MEAT STORED IN NITROGEN AT BELOW—FREEZING TEMPERATURES.)

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