COMPARISON OF FIVE METHODS FOR DETERMINING SALT CONTENT OF MEAT PRODUCTS

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INTRODUCTION

SALT is the most common non-meat ingredient added to meat products. Salt serves several functions in meat products: it dehydrates and alters the osmotic pressure of tissue cells, bacterial growth and subsequent spoilage are inhibited, it contributes to basic flavor characteristics and lowers water activity; and in sausage manufacturing, it aids in the solubilization of the myosin-type proteins of comminuted muscle necessary for emulsifying the fat in emulsion type sausages. The amount of salt used in meat products varies, the type of product, regional preferences, and processors. For any single product, consumers will expect the same degree of saltiness whenever the product is purchased. The need for uniformity of salt content is becoming increasingly important because of increased sales of prepackaged processed meat products.

In 1970, Hibbert and Meara (5) investigated six methods for the determination of salt in meat products. These methods involved electrical conductivity, electrical resistance, and the use of the chloride electrode. However, they did not compare the time required for each method. Since 1970, several new methods have become available, for example, the DICROMAT salt analyzer and the QUANTAB chloride titrator. In this paper, we present the results of a comparative study of five methods and the time required for each of these methods for determining salt content of several types of meat products.

MATERIALS AND METHODS

IN this study, we examined meat products chosen to represent a cross section of various types of meat products: e.g., bacon, wieners, bologna, country cured ham, canned ham, and dry and semidry fermented sausage. Four samples of each type of product were purchased at local retail stores over a period of six months. Each type of product was ground three times and subsamples were taken for determination of salt content for each method involved. For each method, each type of product was analyzed in duplicate or triplicate, and the time required for conducting each of the five analytical phases (grinding, weighing and blending, filtering, digestion, and determination of salt content) was recorded.

Five methods were used in this study: the standard Volhard method for solid and filtrate samples; DICROMAT salt analyzer; QUANTAB chloride titrators; and the chloride electrode. The Volhard method as specified in AOAC procedures (3) served as the standard method for comparison in this study. In general, the Volhard method involves the following steps: (a) addition of 10 ml of silver nitrate (0.5N $AgNO_3$) to about 3 g of meat sample to precipitate the chloride ions as Ag Cl; (b) digestion of meat sample with concentrated nitric acid; (c) back titration of excess silver nitrate with ammonium thiocyanate (0.1N NH_4SCN); and (d) calculation of the amount of silver used to precipitate the chloride ions and conversion of the value to percent sodium chloride with the formula Percent NaCl = [volume of silver nitrate - 0.2 (volume of ammonium thiocyanate/weight of sample] X 2.92.

For the Volhard (filtrate) procedure, we put 20 g of meat product and exactly 200 ml of distilled water in a Waring Blendor jar and homogenized them for 1 min; then we filtered the homogenate through a "Mr. Coffee" filter. Three 25-ml aliquots of the filtrate were removed, and the percent salt content of each aliquot was determined by the standard Volhard method. Percent sodium chloride in each aliquot was calculated according to the formula Percent NaCl = [volume of silver nitrate - 0.2 (volume of ammonium thiocyanate/volume of filtrate] x 32.12.

The DICROMAT salt analyzer (1) functions on the principle of electrical conductivity. The instrument provides a digital readout of salt concentration in solutions having a salt content of 0 to 5%. Procedures for standardizing the analyzer (which includes determining the salt content of a standard filtrate with the Volhard procedure), extraction of salt from the meat samples, and determination of salt content were those described by Diamond Crystal Salt Company (St. Clair, Michigan). Special attention must be given to standardizing the analyzer with a filtrate of each type of meat product that is to be analyzed on any one particular day, e.g., bacon, hams, etc.

QUANTAB chloride titrators, No. 1176 (Ames Co., Division Miles Laboratories, Inc., Elkhart, Indiana), range 0.3-10% NaCl, were also tested in our study. A QUANTAB chloride titrator is a thin, chemically inert plastic strip, about ½ x 3½ inches, in which an absorbent paper capillary column impregnated with brown silver dichromate ($Ag_2Cr_2O_7$) is laminated. When the plastic strip is placed in a salt solution, fluid rises in the column by capillary action. Chloride ions in solution react with $Ag_2Cr_2O_7$ to produce equivalent amounts of white insoluble silver chloride (AgCl). Procedures for preparations of sample and determination of salt content were those described by Vander Werf and Free (6).

An Orion solid-state chloride sensing electrode (Model 94-17) and a double-junction reference electrode, Model 90-02 (Orion Research, Inc., Cambridge, Massachusetts) were used in conjunction with a Corning Digital 112 Research pH meter equipped with a relative millivolt function switch (Corning Scientific Instruments, Medfield, Massachusetts). With this switch, electrode offsets can be corrected with a calibration knob. With this method, salt is extracted from the meat sample with a reagent containing nitric acid to remove possible

interferences by proteins and acetone to prevent clogging of the electrode by fat. Procedures for preparation of the acid reagent, extraction of salt from the meat sample, preparation of standard solutions, and preparation of calibration plot on two-cycle semi-log paper were as described by Orion Research, Inc. (2).

Data were analyzed by the general linear model procedure according to the Statistical Analysis System (SAS) of Barr et al. (4).

RESULTS AND DISCUSSION

THE total time required for conducting each of the five analytical steps was 45 min for QUANTAB chloride titrator; 52 min, chloride electrode; 55 min, DICROMAT salt analyzer; 80 min, Volhard (filtrate); and 85 min, Volhard (solid sample)(Figure 1). The time for analysis was shortest for the QUANTAB method and longest for the Volhard (solid) method. With the QUANTAB method, the water used for extracting salt from the samples of ground meat products can be heated to boiling while the meat samples are being ground and weighed, and the chloride titrator can be placed directly into the filtrate that collects inside of a cone-shaped cup of filter paper that has been immersed in the meat-water extract. The total analytical time could be shortened for the chloride electrode, DICROMAT salt analyzer, and Volhard (filtrate) methods by determining the salt content on the first 25 to 50 ml of filtrate that comes through the filter rather than to wait for complete filtration of the meat slurry, as was done in our study.

Time spent grinding (10 min) and weighing (5 min) was similar for all five methods. An additional 5 min was required for homogenizing the samples for the DICROMAT salt analyzer and Volhard (filtrate) methods. Three of the methods (chloride electrode, DICROMAT salt analyzer, Volhard filtrate) required filtering the meat-water homogenate, which took from 17 to 30 minutes for complete filtering of sample. Filtering time was shortest for the chloride electrode (17 min) method because the acidified acetone reagent eliminates any interference by proteins and prevents clogging of the electrode with fat. Only one of the methods (Volhard-solid sample) required considerable time (60 min) for digesting the sample. About two-thirds of the time spent in conducting the standard Volhard method is spent on digestion of the sample and about one-third on grinding, weighing, and back titration of the excess silver nitrate with ammonium thiocyanate. Research needs to be done on methods for reducing digestion time.

The time involved for the actual determination of salt content for each method was 15 min for QUANTAB chloride titrator; 19 min, chloride electrode; 5 min, DICROMAT salt analyzer; 30 min, Volhard (filtrate); and 10 min, Volhard (solid). The time for the actual determination of salt content by the chloride electrode method is relatively long because of the time required for a stable potential reading and by the Volhard (filtrate) method because of the time required to precipitate the chloride ions as AgCl and back titration of excess silver nitrate with ammonium thiocyanate.

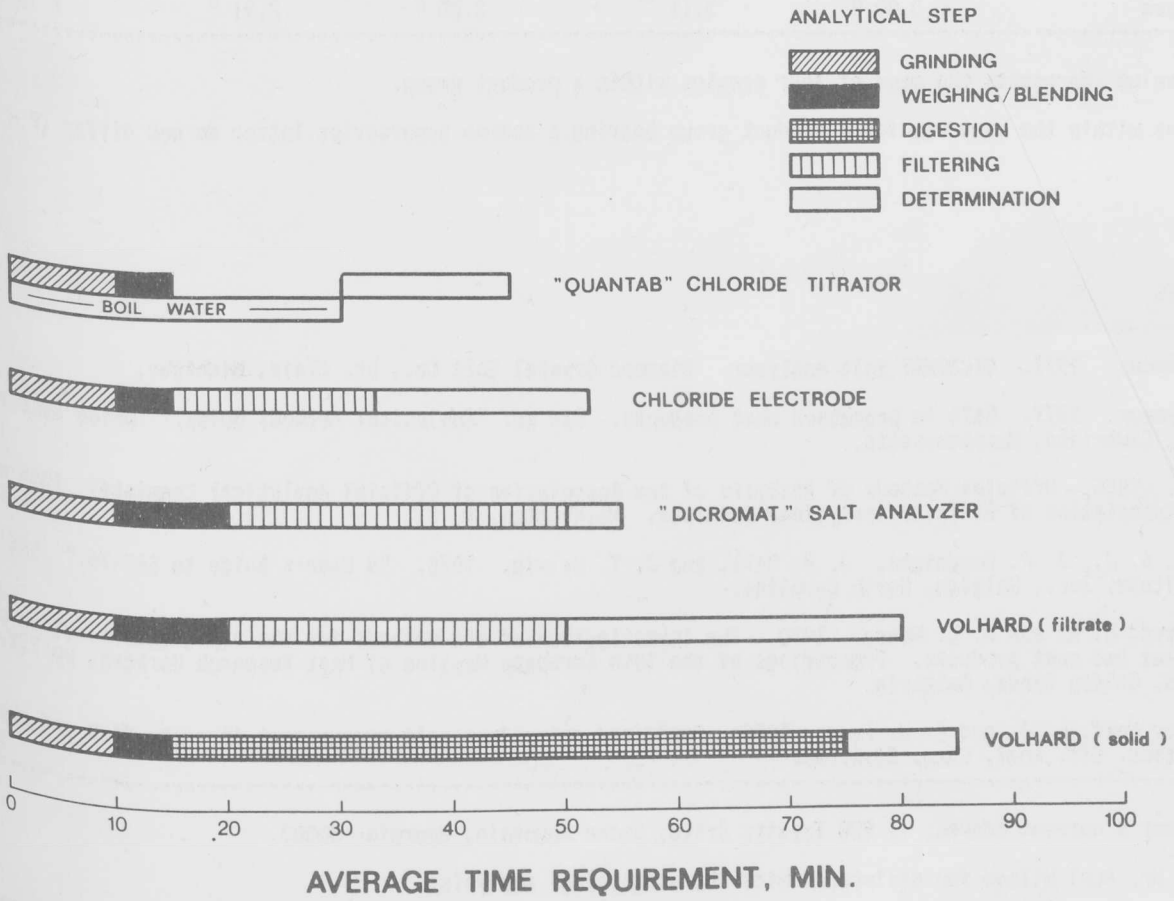

FIG. 1. AVERAGE TIME REQUIRED FOR CONDUCTING EACH OF THE FIVE ANALYTICAL STEPS AND TOTAL TIME REQUIRED FOR EACH METHOD.

Salt content values obtained with the QUANTAB titrator method were higher than values for all other methods; the differences were significant ($P < .05$) except for country cured hams and canned hams analyzed by the chloride electrode method (Table 1). Even though the salt content values were higher for the QUANTAB titrator method, the method has merit for routine control of salt content of meat products during processing. Most meat products have rather wide ranges of salt toleration so that great accuracy becomes unnecessary. With proper sampling, extraction, and dilution techniques, 70% of the results from the titrators are within 5% of the results by the Volhard method.

In general, the values obtained using the chloride electrode, Volhard (filtrate), and DICROMAT analyzer methods agree well with those obtained by the standard Volhard method, with the exception of bacon (Table 1). For bacon, salt content values were significantly higher for the QUANTAB titrator method than for any of the other four methods, and the salt content values for the chloride electrode, Volhard (filtrate), and DICROMAT analyzer were significantly higher ($P < .05$) than those for the standard Volhard (solid) method. The good agreement between the Volhard (filtrate) data and the Volhard (solid) data was expected, because the filtrate was obtained from the same sample of meat that was analyzed for salt content by the standard Volhard method.

Because of the variation in percent salt content obtained among methods for the same meat product, and the time required to conduct each of these methods, it becomes very apparent that research needs to be done on the development of a direct rapid and economical method which can find universal application for the determination of the salt content of all meat products. This is especially true at present because of the high cost of silver nitrate, a compound needed for the standard Volhard method.

Table 1. Percent salt content values for five methods used for determination of salt content of various groups of meat products [a]

Product group	QUANTAB titrator %	CHLORIDE electrode %	Volhard (filtrate) %	DICROMAT analyzer %	VOLHARD (solid) %
Bacon	2.91 [b]	2.52 [c]	2.43 [c]	2.30 [c]	1.92 [d]
Wieners and bologna	3.63 [b]	2.81 [c]	2.80 [c]	2.69 [c]	2.65 [c]
Country cured hams	7.63 [b]	6.79 [b]	7.45 [b]	7.49 [b]	6.66 [b]
Fermented dry sausage	6.20 [b]	4.61 [c]	4.71 [c]	4.74 [c]	4.36 [c]
Fermented semidry sausage	4.10 [b]	3.40 [c]	3.14 [cd]	2.85 [d]	3.10 [cd]
Canned hams	3.80 [b]	3.11 [bc]	2.80 [c]	2.91 [c]	2.76 [c]

a Each value represents the mean of four samples within a product group.

bcd Means within the same row for a product group bearing a common superscript letter do not differ ($P < 0.05$).

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Reference to brand or firm names does not constitute endorsement by the U.S. Department of Agriculture over others of a similar nature not mentioned.