CHANGES OF PHYSICOCHEMICAL AND MICROBIOLOGICAL PARAMETERS DURING CONTROLLED PRODUCTION OF HIGH QUALITY FRANKFURTERS

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SUMMARY

With controlled optimum preselected processing contitions and formulation suitable for high quality frankfurters the study of the changes, which influence yield, quality and shelf life, showed the following: During reddening, drying and smoking a decrease in moisture of 5 percent units occurred. The total weight loss reached 10.23% and the final moisture content was 55.06%. The pH of the meat, initially 5.9, increased in the batter to 6.13 and after heat processing reached 6.33.
In the batter a significant decrease in redness (a+) and of the ratio a/b were observed. During reddening, drying and smoking a significant continuous increase in redness, yellowness and of the ratio a/b occurred. The development of the pink-red color was completed when the internal temperature of frankfurters was 60°C. In the batter the mesophile aerobic count was $5.7X10^7$ cfu/gr, micrococci-staphylococci and enterobacteriaceae $1.0X10^4$, lactobacilli $2.8X10^4$ and Staphylococcus aureus $2.6X10^2$. Considerable decrease of the counts was observed during smoking. Cooking (internal temperature 72°C for 5 min) caused the complete destruction of enterobacteriaceae, lactobacilli and S. aureus while the count of mesophile aerobes had a total decrease of 4.2 log cycles. The micrococci-staphylococci count was reduced only by 1.4 log cycles. From the bacteria studied only the resistant micrococci survived processing in a considerable number.

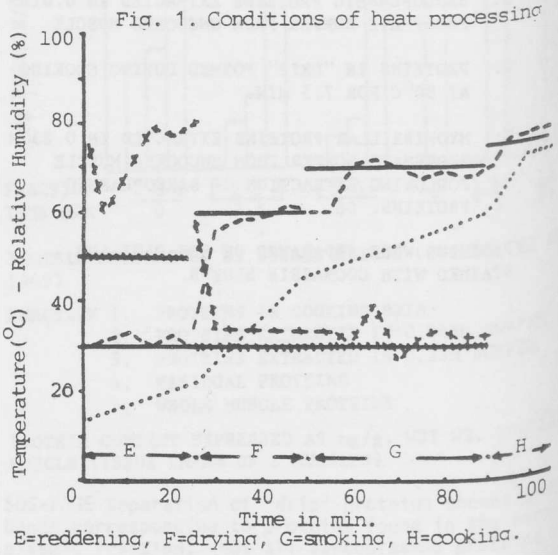
INTRODUCTION

Frankfurters are an emulsion type meat product which is widely consumed and for this reason is of special interest to the meat industry and to the consumer. The quality characteristics and shelf life of the product depends upon the ingredients used in the formulation and the conditions applied during each of its successive processing steps. The object of the present research was to study, under controlled preselected processing conditions and formulation suitable for high quality frankfurters, the physicochemical and microbiological changes which influence the yield, the quality and the shelf life of the product. Also to determine processing and formulation data which result in frankfurters of better quality with a longer shelf life.

MATERIALS AND METHODS

Batches of frankfurters of 27 Kg each were processed in the installation of the Meat Research Center of the Food Science Department in three replications under controlled commercial conditions and formulation suitable for high quality frankfurters, meeting the requirements of the Greek Food Law.
The formulation of the batter consisted of 37.04% lean frozen beef, 14.82% fresh pork meat, 22.22% pork back fat, 18.52%ice/water, 1.85% salt, 0.01% sodium nitrite, 0.11%ascorbic acid, 0.25% polyphosphates, 3.70% potato starch, 0.82% sugar, 0.22% sodium caseinate, 0.18% white pepper, 0.15% red pepper and 0.11% nutmeg.
The beef was imported and was kept frozen at -18°C for 4 months. The pork meat and lard were purchased fresh from the local market of Thessaloniki and kept frozen at -18°C for a few days until their use.
Twenty four hours prior to processing the meats and pork fat were placed in a +2°C cooler for one day's thawing. After partial thawing they were cut in slices 2-3 cm thick and separated in appropriate weights according to the formula.
The beef and pork meat were placed in a 60 lt capacity Killia chopper and coarse chopped for 3 min. Then the salt and the other dry materials were added with slow chopping until the temperature of the meat mixture reached 4°C. After addition of the pork fat the chopping was continued with stepwise addition of ice/water, using the highest speed of blades and bowl rotation, until the batter temperature reached 14°C. The batter was stuffed with a Risco Brevetti vacuum stuffer into 25 mm diameter uncolored cellulose casings and linked 10-12 cm in length. Heat processing started 1/2 hr after preparation of the batter.
The heat processing was done in one truck automatic process oven with the following schedule and preselected settings: reddening at 30°C with 50% RH for 25 min, drying at 60°C with 30% RH for 25 min, smoking at 70°C with 30% RH for 40 min, cooking to an internal temperature of 72°C for 5 min, followed by showering until internal temperature dropped to 25°C. Then the frankfurters were placed in a cooler at +2°C with a relative humidity of 70 to 75% for 24 hrs prior to peeling and packaging.
Based on the measurements made during heat processing the actual temperature and relative humidity conditions which existed in the oven and the development of temperature in the center of frankfurters are given in Fig. 1.

Fig. 1. Conditions of heat processing



E=reddening, F=drying, G=smoking, H=cooking.

——— oven temp. settings
– – – – actual oven temp.
. . . . . internal frankfurter temp.
~~~~~ oven R.H. setting
+ + + + + actual oven R.H

Sampling procedure. During processing two samples of 500 gr weight were taken at the end of the following steps: A) coarse chopping of meats, B) preparation of lean meat mixture, C) final batter, D) stuffing, E) reddening, F) drying, G) smoking, H) after cooking and showering, I) after chilling.
The parameters studied included the determination of weight loss, moisture and fat content, measurement of pH, color, counts of total aerobic mesophilic bacteria, of micrococci and staphylococci, of enterobacteriaceae, of lactic acid bacteria and Staphylococcus aureus.
For weight losses the frankfurters, hanged on two rods, were weighed before heat processing and the weighing was repeated in the subsequent stages of sampling. The difference from the initial weight was expressed as % weight loss.
Moisture and fat content were determined according to
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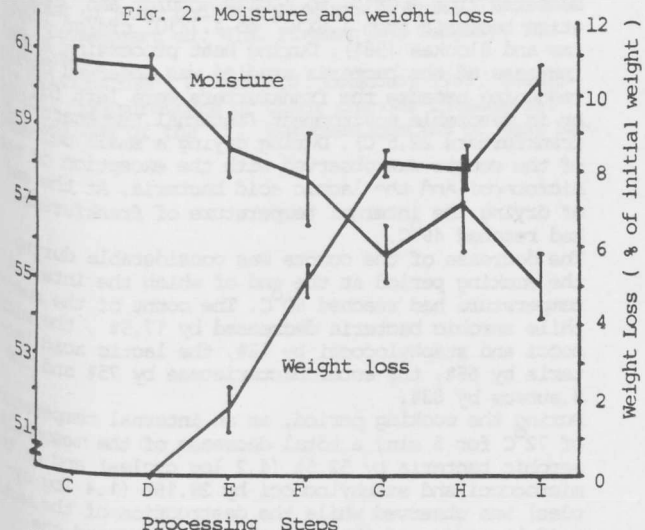
AOAC procedures (1980). For pH determination a 20 gr sample was blended with 180 ml water and the average of three readings of the resulting slurry was obtained. Product color was determined with a Labscan (Hunterlab) Model LS 5000 spectrocolorimeter. Color values, L, a(+), b(+), were measured at 5 five different positions on the skin and on the core of 3 cm thick slices and the average of the measurements was recorded. For microbiological analysis a 20 gr sample was obtained aseptically and it was homogenized in a sterilized glass blender cup with 180 ml of sterilized 0.1% peptone water. From the prepared serial decimal dilutions duplicate plates were prepared with the following media and incubation conditions: a) for total aerobic count APT agar (Merck) at 25°C for 3 days, b) for micrococci and staphylococci Manitol Salt agar (BBL) at 37°C for 2 days, c) for enterobacteriaceae Violet Red Bile Glucose agar at 37°C for 24 hrs, d) for lactic acid bacteria Rogosa L.S. agar (Merck) at 25°C for 3 days and, e) for Staphylococcus aureus Baird Parker agar (Merck) at 37°C for 48 hrs.

RESULTS AND DISCUSSION

1) Moisture content and weight loss. The % of moisture content and the weight losses in the various steps of production of frankfurters are shown in Fig. 2. The average moisture content of the batter was 60.80% and the fat content, on dry basis, was 61.26%. During reddening, drying and smoking, in which heating was done by hot air, a significant decrease ($P<0.05$) of the moisture content of 5 percent units was observed which was accompanied by a significant increase ($P<0.05$) of the weight loss, which at the end of smoking amounted to 8.23% of the initial weight of frankfurters. During cooking, the moisture content showed a significant ($P<0.05$) increase of 1.4 units while the weight loss had a smaller and nonsignificant ($P>0.05$) decrease of 0.3 units.

Fig. 2. Moisture and weight loss

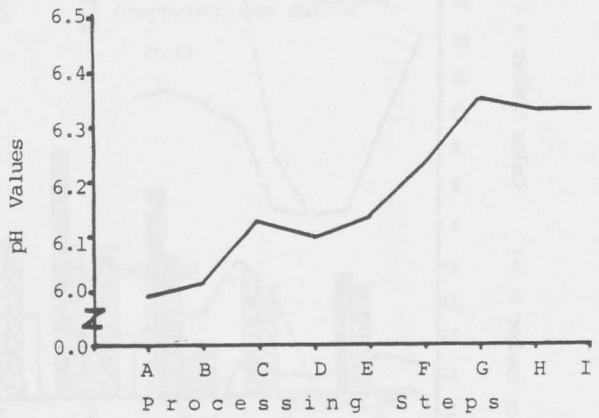


C=batter, D=stuffing, E=reddening, F=drying, G=smoking, H=cooking and showering, I=chilling.

During chilling the moisture content had a significant ($P<0.05$) decrease of 2.2 units and the weight loss increased significantly ($P<0.05$) by 2.3 units. The total weight loss during the production of the frankfurters reached 10.23% and this result agrees with the data of Kramlich (1971) who found that the weight losses during heat processing of frankfurters ranged from 8 to 10% of the their initial weight. The final moisture content of the frankfurters, after chilling at 2°C for 24 hrs, was 55.06% while the final fat content, on dry basis, was 57.96%. Both values are within the limits of the Greek Food Law (1983) which sets upper limit for moisture at 53% with 2 units tolerance and for fat content, on dry basis, at 60%.

2. pH. The development of pH in various steps of production is presented in Fig. 3.

Fig.3. Changes in pH during processing



A=meat, B=lean meat mixture, C=batter, D=stuffing, E=reddening, F=drying, G=smoking, H=cooking and showering, I=chilling.

The average pH value of the meat used in the study was 5.9. According to Wirth (1985), for the production of frankfurters, the most suitable beef meat has pH greater than 5.8 and that of pork meat a pH greater than 6. The high pH meat which is used for frankfurters influences favorably the water holding capacity and increases the quantity of the extracted proteins. The average pH of the batter was 6.13 and differed significantly ($P<0.05$) from the pH of the meat. The observed increase was mainly due to the addition of the pork fat.

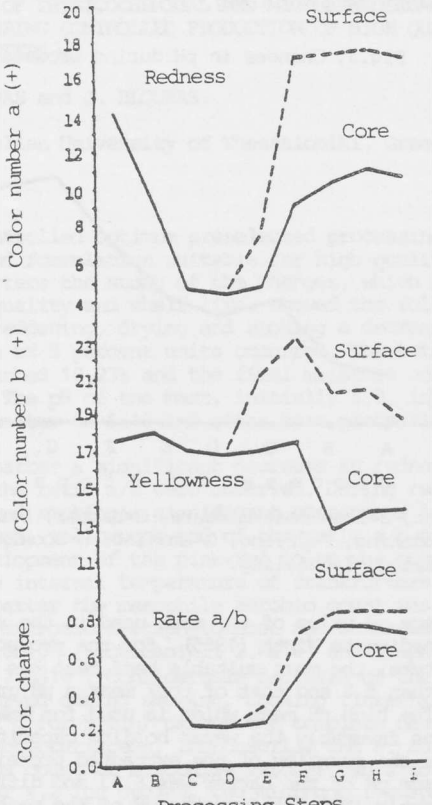
During heat processing a further significant ($P<0.05$) increase of 0.22 units was observed. An increase of the pH value during heat processing from 0.2 to 0.5 units has been reported by other investigators and it is attributed mainly to the concentration of basic non protein nitrogen compounds.

3. Color development. The color values of a(+) (redness) and b(+) (yellowness), measured in the various steps of production, as well as the ratio of a/b values (Koivistoinen and Loukimo, 1969) are presented in Fig. 4.

During coarse chopping of the meat a bright red color developed due to the oxygenation of myoglobin (Wirth, 1986). During preparation of the lean meat mixture and of the final batter a significant ($P<0.05$) decrease in redness and of the ratio a/b was observed and the batter acquired a light brown color. These changes are due to the formation of metmyoglobin.

During heat processing and especially during reddening, drying and smoking a continuous significant ($P<0.05$) increase of redness and yellowness and of the ratio a/b were observed. These changes are attributed to the formation of nitrosomyoglobin which upon heating is converted to nitrosyl hemochrome, which stabilizes the pink-red color of the frankfurters. The nitrosomyoglobin results from the reaction of nitric oxide (NO) with myoglobin. The conversion of the nitrites to NO is influenced by the temperature and the pH of the batter as well as by the presence of reducing substances (ascorbic acid) and time (Wirth 1986). The color changes were more pronounced at the surface than in the core of the frankfurters. This can be explained by the temperature difference which existed during processing between the surface and the center of the frankfurters. At the end of the smoking period, when the development of color was completed, the temperature in the oven and thus that on the surface of the frankfurters was 70°C while the internal temperature

Fig.4.Color development

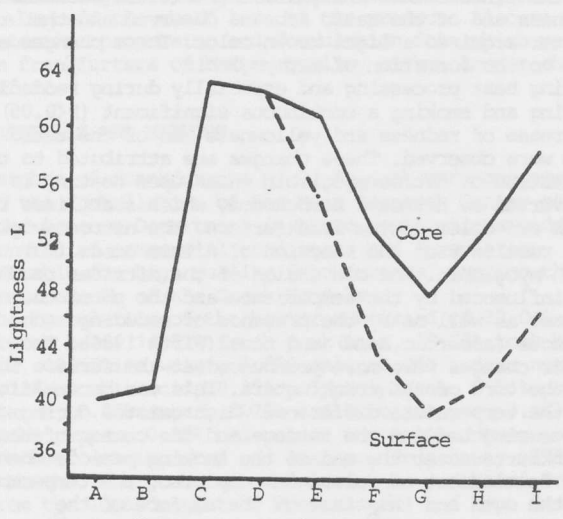


A through I explained in Fig.3.

was 60°C. Fox et al (1967) reported that the temperature during heat processing is the most decisive factor which influences the rate of color formation and its maintenance during storage. According to the same investigators the color formation of frankfurters made with addition of ascorbic acid takes place as the center temperature increases from 43°C to 60°C and is completed at 65°C.

The changes in L value (lightness) of the frankfurters are presented in Fig. 5.

Fig.5.Lightness (L value) during processing



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The lightness of the meat mixture showed an almost vertical increase after the addition of the pork fat and ice/water during preparation of the batter. During reddening, drying and smoking a significant ($P<0.05$) decrease in lightness was observed which was significantly greater at the surface of the frankfurters. On the contrary during cooking and chilling a significant increase in lightness was observed both at the surface and in the core. The observed differences in lightness during processing are attributed to the changes caused by heating on the structure of frankfurters and their moisture content both of which influence the amount of reflected light.

4. Microbiological counts. The population of the microorganisms studied at the various steps of production is shown in Fig. 6.

During coarse chopping of the meats the count of mesophile aerobic bacteria was $3.2X10^7$ cfu/gr, of micrococci and staphylococci $1.10X10^4$ cfu/gr, of the enterobacteriaceae $1.0X10^4$ cfu/gr, of the lactobacilli $2.7X10^2$ cfu/gr and that of S. aureus $2.60X10^2$ cfu/gr. Paneras and Bloukas (1981) found similar counts of the above bacteria in thawed imported beef meat, which was used for industrial production of fermented sausages.

In the lean meat mixture the population of micrococci and staphylococci showed a small increase of 0.6 log cycle. This was due mainly to the bacteria of the added substances, especially the spices.

The count of the mesophile aerobic bacteria in the batter was $5.7X10^7$ cfu/gr without showing any appreciably increase. However a considerable increase of 2.1 and 1.0 log cycles was observed for the lactic acid bacteria and the enterobacteriaceae respectively. This increase is attributed to the high counts of the pork fat, which was added to the meat mixture in a considerable amount (22.22%) of the batter). Pork fat used in the production of fermented sausages was found to have a population of lactic acid bacteria from $1.0X10^3$ to $4.0X10^4$ cfu/gr and Gram negative bacteria from $1.8X10^4$ to $4.7X10^6$ cfu/gr (Paneras and Bloukas 1981). During heat processing a small increase of the bacteria studied was observed during reddening because the frankfurters were left for 1/2 hr in favorable environment (internal temperature of frankfurters 22.5°C). During drying a small decrease of the counts was observed with the exception of the micrococci and the lactic acid bacteria. At the end of drying the internal temperature of frankfurters had reached 46°C.

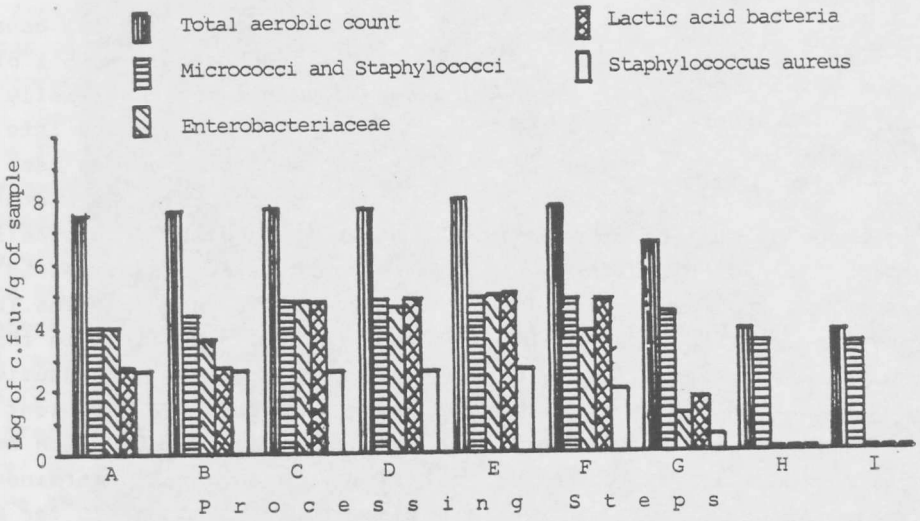
The decrease of the counts was considerable during the smoking period at the end of which the internal temperature had reached 60°C. The count of the mesophile aerobic bacteria decreased by 17.5% , the micrococci and staphylococci by 12%, the lactic acid bacteria by 66%, the enterobacteriaceae by 75% and the S.aureus by 83%.

During the cooking period, at an internal temperature of 72°C for 5 min, a total decrease of the mesophile aerobic bacteria by 52,5% (4.2 log cycles) and of the micrococci and staphylococci by 29.16% (1.4 log cycles) was observed while the destruction of the lactic acid bacteria, of the enterobacteriaceae and the S.aureus was complete.

The rusults showed that from the bacteria studied the micrococci and staphylococci are the only bacteria which survived at considerable level in the final product.

The S.aureus was completely destroyed at 72°C. According to Palumbo et al (1977) frankfurters receiving heat treatment at an internal temperature of at least 66°C are free from S.aureus and any presence of S. aureus in the final product is due to post-contamination after heat treatment.

Fig.6.Microbiological counts during processing



A through I explained in Fig.3.

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