D36

INFLUENCE OF THE TEMPERATURE ON THE ELECTRICAL CONDUCTIVITY OF SAUSAGE-TYPE EMULSION

C. CURT and P. EYNARD
CEMAGREF - Division Technologie des Industries Agro-Alimentaires - Domaine de Laluas - 63200 RIOM
FRANCE

1. Keywords

Electrical conductivity - Meat emulsion - Temperature coefficient

2. Background and objectives

The chopping phase is a main stage during the manufacture of frankfurter-type sausages: the different components are structured into an homogeneous mixture, then the product's quality after thermal processing and particularly the losses during cooking (2) depend on this stage. The control of the emulsification is therefore very important. The use of electrical conductivity for this purpose has been studied (3,4) However conductivity is dependent of temperature and this parameter increases during chopping because of the energy created by the rotating knives. This phenomenon, if not taken into account, would create a bias in the establishment of the relation between the structure of the emulsion and its conductivity. The relative variation of conductivity against temperature is within the range 0.015-0.07 $°C^{-1}$, depending on the type of solution: for water, salt solutions, it is about 0.02-0.03 $°C^{-1}$ (1), for milk, 0.020-0.025 $°C^{-1}$ (6), for sugar solution, 0.02 $°C^{-1}$ (5) and for muscle, the influence of temperature on resistivity is around -0.02 $°C^{-1}$ (7) Moreover, the temperature coefficient is usually itself a function of temperature.

The aim of the present study is to characterize, for different chopping times, the evolution of the conductivity *versus* the temperature by determining temperature coefficients using 2 models: this will allow to eliminate the temperature parameter in the establishment of the relation between structure and conductivity.

3. Methods

The composition of the mixture corresponds to that of frankfurter-type sausages: 40 % lean meat, 30 % water, 30 % fatty tissue ; common salt concentration is 2 %. The times of chopping tested are 115, 130, 145, 180, 215, 250, 280, 310, 340, 370 s. This range of time allows to work on the different types of structure of the emulsion. The conductivity of the emulsion is measured using an electrode (WTW, LTA/S) with a cell constant of 1 cm^{-1}, connected to a conductivity meter (WTW, LF 530). Temperature and conductivity are jointly recorded on 10 samples of 100 ml of emulsion, for each processing time.

The temperatures are within the range 12-30 °C. For the lowest times, i. e. 115 to 180 s, the temperature of the emulsion is below 18 °C: the samples are warmed with a water-bath at 35 °C. For the upper times, 215 to 370 s, the temperature is above 18 °C: the samples are cooled into a water-bath at 5 °C.

The first points of the graph conductivity *versus* temperature, which correspond to the installation of a thermal equilibrium of the electrodes, are eliminated. Temperature coefficient is determined by regression analysis according to two models: (1) $C = aT + C_0$ and (2) $C = C_0 (1 + b (T - T_0))$ with C: conductivity at T °C, C_0: conductivity at T_0 =18 °C, a (mS/cm °C) and b (%/°C): temperature coefficients. Calculations are led by using for each sample its own conductivity at 18 °C, because of its high variability (cf. table 1).

4. Results and discussion

Table 1 sums up the values of the temperature coefficient, in function of processing time and model. The correlation coefficients between conductivity and temperature are higher than 97.66 %, the two models are appropriate within the range of temperature studied.

The analysis of variance shows that there is no significant difference between the coefficient evaluated during an increase of temperature and that determined during a decrease (cf. figure 1): it is therefore possible to carry out the experiments for determining the influence of the temperature on the conductivity using any of these two thermal treatments.

Two sources of heterogeneity affect the value of the conductivity; they come from:

- composition: this parameter is not completely controlled, due to the presence of lipids in the lean meat and that of proteins in the fatty tissue. The composition influences the conductivity because the various components of the emulsion get conductivities at the same temperature very different one from another (cf. figure 2).
- chopping time and final chopping temperature: at the intermediate chopping times, i. e. 145-180 s, the emulsion is visually more homogeneous; this homogeneity is pointed out by the coefficients a and b and the conductivity at 18 °C for which the standard error is the lowest (cf. table 1). In the case of short chopping times, the emulsion presents pieces of fatty tissue inside the homogeneous mixture of proteins, water and salt; this leads to high standard errors onto the coefficients a, b and the conductivity. At long chopping times, i. e. above 340 s, it is difficult to conclude, due to the possible melting of fat which introduces locally an important variation of a, b and of the conductivity.

The mean values of temperature coefficients at the different processing times are compared by the analysis of variance:

• model 1: if the values at 115 s and 340 s, which are lower than those at the other times because of heterogeneities are not taken into account, it can be considered that there is no significant differences between the temperature coefficient at the various chopping times ; a is estimated to 0.306 mS/cm °C.

• model 2: the coefficient b is considered to be the same at 115 s, 130 s, 145 s: 0.0230 $°C^{-1}$; 180 s, 215 s, 250 s: 0.0208 $°C^{-1}$; 280 s, 310 s, 370 s: 0.0217 $°C^{-1}$.

According to the standard error, the second model is the most reliable.

5. Conclusion

Numerous studies have been carried out to evaluate the potentialities of the conductimetry to characterize various quality parameters (composition, maturation...) on food products. Our study on sausage-type emulsion shows up on one hand, that 2 models are appropriate to describe the temperature coefficient and, on the other hand, that the thermal treatment (cooling or heating) of the sample do not influence the results. In the case of the model 2, the temperature coefficient is depending on the chopping time, contrary to the model 1. The values determined, i. e. 0.020 $°C^{-1}$, agrees with the data found in the literature about salt solutions and food products. Thus, the temperature parameter can be eliminated from the establishment of the relation between structure and conductivity.

6. Literature

(1) **BENOIT P. et DERANSART E., 1976.** La conductivité - définition : loi de la conductivité. In BENOIT P. et DERANSART E. (ed.), Les mesures physico-chimiques dans l'industrie, 225-232, Technique et Documentation : Entreprise Moderne d'Edition, Paris.

(2) **GIRARD J. P. AND DANTCHEV S., 1983** Effect of cutting duration on some technological properties of the sausage meat of emulsion-type sausages. Meat Industry, 2, 51-55.

(3) **KATO A., FUJISHIGE T., MATSUDOMI N., KOBAYASHI K., 1985.** Determination of emulsifying properties of some proteins by conductivity measurement. Journal of Food Science, 50, 56-62.

(4) **MORISSON G. S., WEBB N. B., BLUMER T. N., IVEY F. J., HAQ A., 1971.** Relationship between composition and stability of sausage-type emulsions. Journal of Food Science, 36, 426-430.

(5) **OBERT J. C., 1980.** Les capteurs en sucrerie. In Les capteurs et les industries agro alimentaires - l'intégration des capteurs dans les machines et systèmes en vue de leur automatisation, 127-146, APRIA.

(6) **ROEDER, 1931 cited by PRENTICE, 1962.** The conductivity of milk - the effect of the volume and degree of dispersion of the fat. Journal of Dairy Research, 29, 131-139.

(7) **SALE P., 1972.** Appareil de détection de viandes décongelées par mesure de conductance électrique. Supplément au Bulletin de l'Institut International du Froid, 2, 265-274.

7. Data

	Conductivity (mS/cm)			Temperature coefficient model 1 - mS/cm°C			Temperature coefficient model 2 - %/°C		
Time (s)	Mean	Standard deviation	Error (%)	Mean	Standard deviation	Error (%)	Mean	Standard deviation	Error (%)
115	12.11	1.44	11.89	0.271	0.0380	14.02	2.365	0.301	12.72
130	13.20	1.37	10.37	0.320	0.0317	10.06	2.349	0.208	8.85
145	14.79	0.69	4.66	0.302	0.0097	3.21	2.177	0.046	2.11
180	14.97	0.87	5.81	0.311	0.0206	6.62	2.071	0.060	2.93
215	13.83	0.79	5.71	0.309	0.0389	12.62	2.050	0.208	10.15
250	14.00	0.58	4.14	0.299	0.0134	4.47	2.129	0.106	5.01
280	15.08	0.64	4.24	0.305	0.0278	9.11	2.202	0.119	5.40
310	14.86	1.54	10.36	0.277	0.0188	6.78	2.195	0.107	4.87
340	15.61	1.71	10.95	0.261	0.0460	17.74	1.754	0.266	15.16
370	13.63	0.66	4.84	0.340	0.0149	4.38	2.075	0.047	2.26

Table 1: Values of the conductivity at 18 °C and the temperature coefficients (models 1 and 2)

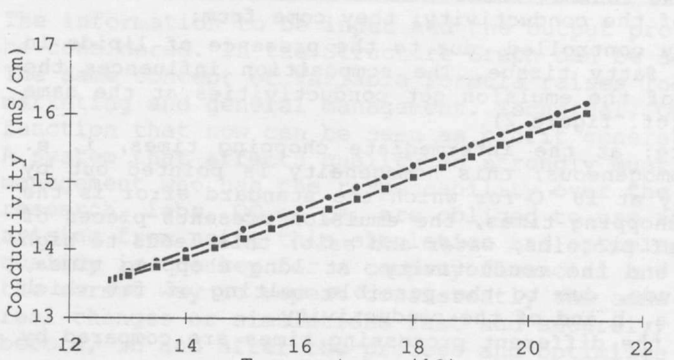

Figure 1: Evolution of the conductivity vs temperature when the sample is cooled then warmed

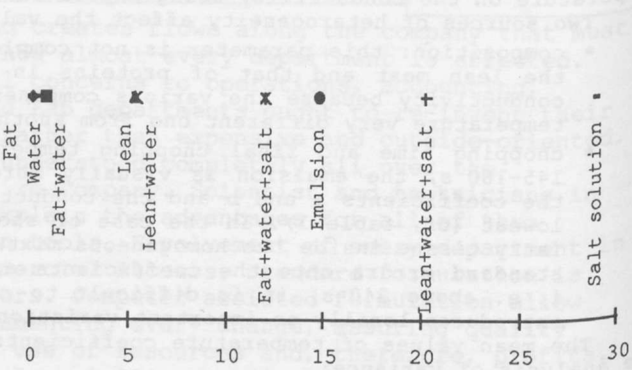

Figure 2: Range of conductivities for the different components of meat emulsion