A nomographic method of optimizing the nutritive value of meat with different regimens of heat treatment

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The problem of whether the technological (temperature-time) regimens selected in industry, guarantee the preservation of the nutrient and biologically active substances important for the physiology of nutrition, is rather topical and justified.
It is generally known that, in the heat treatment of meat, apart from the indices of F-effect (the index of the temperature inactivation of microorganisms) and sensory score, all the remaining indices are neglected. Changes in the nutritive value could be pointed out as an example: they include the reduction of vitamins, amino acids, reduced digestibility, availability, etc. For this reason, a number of indices appeared in literature lately, which represent nutritive value, as additions to the evaluation using F-effect, such as Q-value, CH-value, C-value, etc. (19, 10, 3, 5, 7). These are approximated mathematical methods of predicting the quantitative changes of a given substance, with definite temperatures and time of heat treatment.
Vitamin B_1 (thiamin) serves most frequently as an indicator, reflecting changes in nutritive value upon the heat treatment of meat (9, 5, 8). Thiamin is one of the sensitive and thermolabile meat components, whose reaction kinetics of degradation is known (15, 17, 2, 18).

Material and Methods

400-g cans of veal, 99 x 73, subjected to rotary sterilization, were used.
Vitamin B_1 was determined spectrophotometrically by Gassmann's (1) thiochrome method.
Quantitative changes in SH-groups were determined spectrophotometrically by the method of Sedlak et al. (6).
Sensory evaluation was made with the help of trained tasters, using Peryam's (4) 9-score hedonic scale.
Shear force was determined using Zakhariev and Stoimenov's (16) AKM-1 apparatus.

Results

The results of the studies on the sterilization of veal in 400-g cans are shown in Table 1. It becomes obvious from it that, on sterilizing cans at 121°C for 45-50 and 55 min., the average vitamin B_1 reduction constitutes 36%. In the sensory evaluation, the cans obtained an "excel-

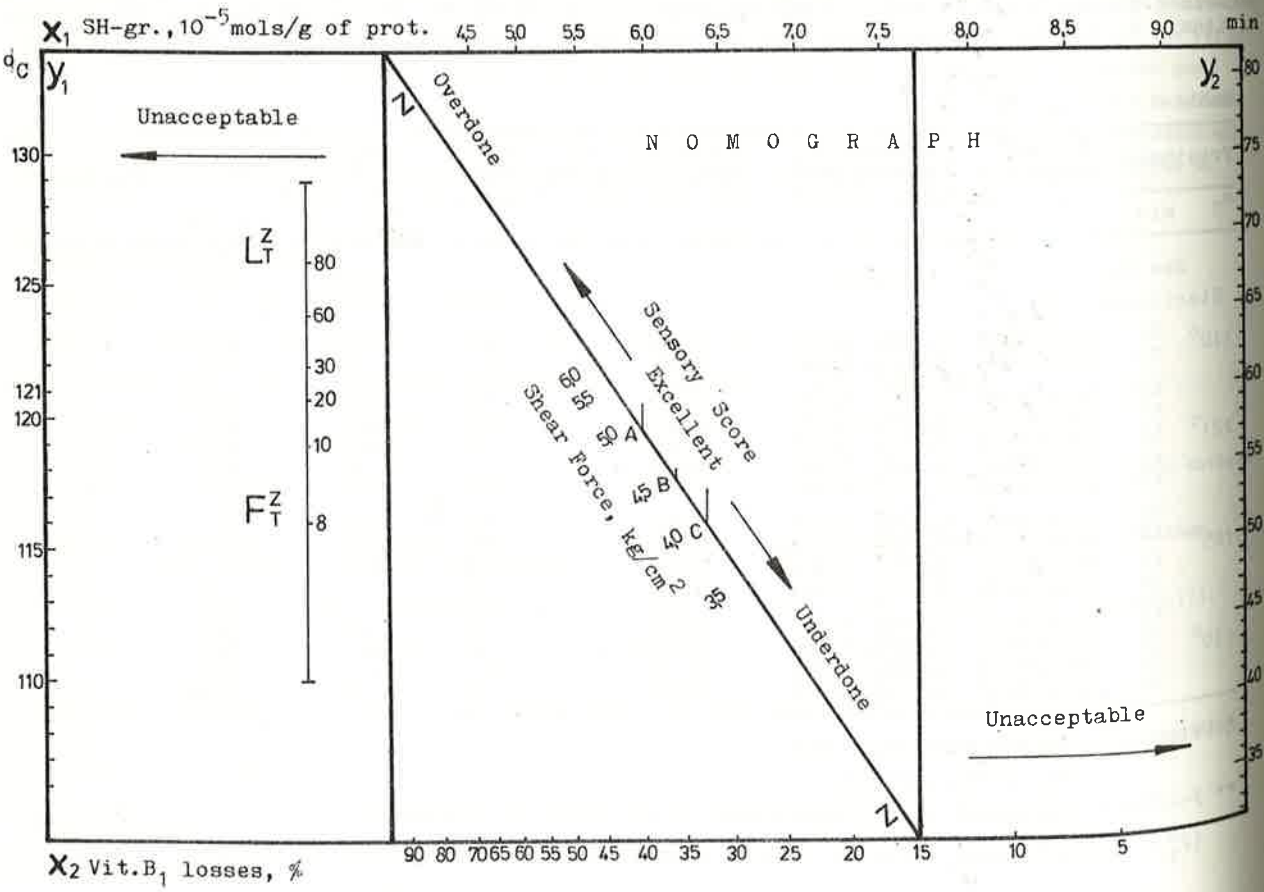
Table 1. n = 6

Treatment °C	min.	Sensory Score	Vitamin B_1, mg/100 g of dry matter*	Vitamin B_1 reduction, mg per 100 g of dry m.	Vit. B_1 reduction, %	SH-groups, 10^{-5} mols per g of protein	Shear force, kg/cm^2	F-effect**
Raw meat			0,7317	-	-	9,86	3,05	-
Sterilized meat								
110°	85	Very good	0,388± 0,006	0,344	47	5,69	6,00	+
	75	Excellent	0,433± 0,007	0,299	41	5,98	5,24	-
121°	60	Very good	0,417± 0,005	0,314	43	5,80	5,49	+
	55	Excellent	0,439± 0,006	0,293	40	6,00	5,11	+
	50	Excellent	0,469± 0,009	0,263	36	6,36	4,60	+
	45	Excellent	0,498± 0,006	0,234	32	6,44	4,09	+
	40	Very good	0,519± 0,005	0,212	29	6,67	3,71	+
125°	52	Very good	0,425± 0,004	0,307	42	5,85	5,37	+
	48	Excellent	0,447± 0,005	0,285	39	6,04	4,98	+
	40	Excellent	0,491± 0,006	0,241	33	6,41	4,22	+
	36	Very good	0,513± 0,004	0,219	30	6,63	3,83	+
130°	42	Very good	0,425± 0,005	0,307	42	5,84	5,36	+
	38	Excellent	0,454± 0,004	0,278	38	6,11	4,85	+
	34	Excellent	0,483± 0,006	0,248	34	6,21	4,34	+
	30	Very Good	0,513± 0,003	0,219	30	6,58	3,83	+

* Vitamin B_1 in raw meat, 0,18 mg%
(Dry matter, 24,6%)

** F-effect designated by (-) means that it is below the minimum of the necessary lethality (F_T^Z), and (+) means, that the actual lethality is higher than the necessary one ($L_T^Z \geq F_T^Z$).

lent" score. The cans sterilized at 121°C for 40 min. have a lower per cent vitamin B_1 reduction: 29%, but their sensory score is 'very good', which points to an insufficiently cooked product.
With the lengthening of sterilization time at 121°C: 45, 50, 55 min., SH-groups decrease. This is probably due to their oxidation, connected with the formation of S-S bridges and H_2S and H_2O release (14, 11, 12, 13).
Shear force varies from 4,09 to 5,11 kg/cm², with 45, 50 or 55 min of sterilization at 121°C. The analyses for the determination of per cent vitamin B_1 reduction, sensory evaluation, the determination of SH-groups and shear force were made with sterilizing cans at 110°C, 125°C, and 130°C.
On the basis of our data and verified literary data, 12 two-dimensional graphs were constructed and plotted in one plane (19). We compensated for the lack of a method of confidence interval of nomographs, familiar to us, by the statistical processing of the results of each index by itself by the NORLOG programme of variance analysis according to Student-Fisher, using a computer. The worked-out correlations of the nomograph were tested and checked repeatedly by the preliminary setting of some of the given parameters under production conditions and their complete coincidence with the expected laboratory results. This fact could be explained by that the indices grounding the nomograph are functions of temperature and time.
Constructionally, the nomograph was made in the following way: temperature, °C, was plotted on the ordinate Y_1; time of heat treatment, min., on Y_2; vitamin B_1 losses, %, on the abscissa X_1; the content of SH-groups, mols/g of protein, on X_2; sensory evaluation and shear force, kg/cm², on Z. The highest sensory score, 'excellent', is plotted on straight line Z between points A and C (Fig. 1).
To find out, whether a temperature regimen is optimal or not, if only the temperature and time of heat treatment are known about it, one should proceed in the following way:
1. Connect with a straight line the given values of the parameters, temperature and time, located on the two ordinates, Y_1 and Y_2.
2. Read off consistency and sensory score from the intersection point of the straight line drawn and line Z.
3. Drop two perpendiculars on X_1 and X_2 from the same intersection point on straight line Z, and read off the per cent vitamin B_1 loss and the degree of denaturation (SH-groups/g of protein) from them.
The present nomograph allows to solve also the reverse problem, to construct new technological regimens, optimal in terms of the product nutritive and biological value. To do this, it is enough to draw a straight line through point B lying on straight line Z. The two ends of the straight line drawn will indicate, on Y_1 and Y_2, the time and temperature necessary to obtain a product of a high sensory score, minimum vitamin B_1 losses, of a juiciness and tenderness, and also of minimum losses of a number of other nutrients.
The results of the studies allowed to construct, for the first time, a nomograph for optimiz-



ing sterilization processes. Optimization is done using more than one index, unlike in the mathematical methods known so far internationally for the purpose. Existing regimens can be controlled using the present nomograph, provided two parameters are known, no matter which ones. The nomograph allows to use also higher sterilization regimens, above 121^{o}C, without affecting meat nutritive value. In this way, savings in time, labour and funds can be achieved in the technological processing of meat.

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