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EFFECT OF MICROWAVES THAWING ON BEEF QUALITY

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## EFFECT OF MICROWAVES THAWING ON BEEF QUALITY

Our present knowledge of the nature and mechanism of microwaves as a source of high-frequency heat has indicated the possibility of their application in meat technology. Microwaves, owing to their length and a high quantity of energy, are characterized by even distribution and absorption in the environment with a higher moisture content. Since the muscle tissue, i.e. meat, is the environment which meets these requirements for the application of microwaves, the study of the possibility of applying microwaves in thawing is of great interest.

A lot of research has been done so far in studying the effects which ultraviolet and other ionizing radiations, high-frequency current and X-rays have upon the biochemical, physico-chemical and morphological changes of meat, as well as upon colour changes and inactivation of enzymes (4, 1, 3, 7, 8, 10, 11, 12 and 13).

We have not found in the literature any information as regards the application of microwaves in meat thawing. The purpose of our study was to examine the possibility of microwave thawing beef of various structure (without fatty tissue - m. quadriceps femoris, interpenetrated with fatty tissue-neck and musculature with layers of fatty and connective tissues - flank). In addition to determining the method of

application of microwaves and maximum time of radiating frozen meat, we wanted to find out if there were any differences in the rate at which glycolytic changes occur in the samples thawed by microwaves and those thawed in the usual way - in the air. Likewise, it was of interest to determine if there were any differences in organoleptic properties of the samples tested.

#### PROCESSING PROCEDURE

Raw Material.- For the experiment we employed fresh beef, i.e.m. quadriceps femoris, flank and neck. Connective and fatty tissues had been removed from m. quadriceps femoris and neck. The meat was cut in uniform, cca 3 cm. thick pieces, weighing 200 grams. In the pieces alcohol thermometers (with the scales graded  $-50$  to  $+30^{\circ}\text{C}$ ) were inserted (up the geometrical center). The samples were frozen for 24 hours at the temperature of  $-10^{\circ}\text{C}$ .

Thawing was done by means of microwaves and by air, at room temperature (cca  $22^{\circ}\text{C}$ ). In all cases, the thawing operation was continued until the temperature in the center of the piece reached  $-1^{\circ}\text{C}$ . The time required for this was measured. Thawing by microwaves was carried out by means of a calibrated therapeutic generator - frequency: 2840 MHz, wave length: 12.5 cm. We employed the method of radiation field with a unipolar electrode. The distance between the top of the emission antenna and the center of the meat piece was 7 cm. The microwaves of flux 120 W were employed.

Prior to refrigeration and after thawing, we determined the sample weight, the pH value, percentage of glycogen; free, total and bound water contents and made organoleptic evaluations of colour as well as microscopic examinations.

Measurements of the pH value were made (meat : water = 1 : 4) by means of Pye's pH-meter.

The glycogen content was determined by means of Drozdov method (11).

The percentage of free water was determined by Graau's method (4), modified by Sonja Karan-Djurdjić(7).

Moisture content was measured by drying method up to the constant weight, at 105°C.

#### RESULTS OF ANALYSIS AND DISCUSSION

Frozen meat exposed to high frequency-current thaws very quickly owing to the length (in cm.) and high energy content of microwaves. The thermal effect of microwave energy, on which is based its application in thawing, is due to the absorption of energy in the field of irradiation. Muscles, i.e. meat, as a tissue which has a high liquid content, are characterized by good absorption of microwave energy, owing to a high dielectric constant, good conductivity and reflexion

on limiting layers.

If we compare the time required for thawing a beef cut by means of microwaves and for thawing it in the air, we notice considerable differences. Assuming that thawing by means of microwaves may bring about changes in physico-chemical processes, we made parallel organoleptic and chemical analyses of beef cuts thawed by means of microwaves and cuts thawed in the air (control samples).

Organoleptic changes caused by microwaves which occur in thawed meat, are negligible. There is practically no difference between the colour of meat thawed by means of microwaves and the colour of fresh meat, except for the brilliance of the surface which is somewhat less intense. However, the control samples - thawed in the air, have a darker colour with a slightly greyish shade.

The colour differences between the samples treated in one and the other way are to be expected, for the oxidation of the meat pigment depends on the length of exposure to air or oxygen, as well as on the temperature. During thawing in the air, at the temperature of  $22^{\circ}\text{C}$ , there is much more time for these processes to develop, than during thawing by means of microwaves which lasts a short time.

We achieved (9) the best results with the microwaves of flux 120 W, because the quantity of heat was sufficient for thawing even 5 cm thick pieces without causing thermal congealment of the surface layer. Likewise, since on the basis of our previous experience, the most convenient distance

between the radiation source and the treated meat could be selected, no secondary thermal effect occurred on the surface of the irradiated cuts which would have an unfavorable effect on meat taste and odour. We did not find any differences in taste and odour between the cuts thawed by microwaves and those thawed in the air.

Weight loss.- The results obtained previously and those obtained in the present experiment varied to a great extent as regards the weight loss - in dependence of the thawing method. The average weight loss values in the microwave thawing method are less than percent - namely around 0,5 percent. In contrast to this, thawing in the air causes the greatest weight loss (the average loss is 3.4% and the maximum loss is 5.8%) (9). The drip loss has undoubtedly an effect upon the quality of thawed meat. Therefore, the application of microwaves has a great advantage over the other methods which cause a much higher weight loss during thawing.

C h e m i c a l analyses (table 1) show that in the two thawing methods there are considerable differences as regards the content of total and free water contents the glycogen content and the pH values.

The percentage of the total water content is higher in samples thawed by means of microwaves which is in accord with the weight loss. The analysis of the muscles shows that in both thawing methods the water loss is the highest in muscles with the lowest fatty tissue content. The average

water loss in microwave thawing is about 0.5 percent, while in the other method it is five to six times higher.

The results of the analysis of the free water content are very interesting. The highest free water content is found in meat cuts thawed by microwaves - up to 19.72 percent in m. quadriceps femoris, while in controls it is considerably lower - maximum 15.46 percent in neck. It is worth pointing out that free water content in samples thawed in the air varies because the muscle with the lowest fatty tissue content - m. quadriceps femoris - has the lowest free water content and the highest bound water content. The average values of free water content appear to be about six times higher in samples thawed by microwaves and about four times higher in samples thawed in the air than they are in fresh meat.

The results of the analysis of the pH value show that beef cuts treated by microwaves have in all cases higher pH values than control samples thawed in the air. These differences are more readily observable in m. quadriceps femoris, while in neck and flank they are negligible. In comparison with the initial pH values measured within 3 hours after slaughter in both thawing methods the highest pH reduction is found in m. quadriceps femoris and the lowest one in flank.

The decrease in the glycogen content is much greater in samples thawed in the air. In microwave thawing, the glycogen content is reduced on the average 13 times, while in thawing in the air, it is reduced 18 times. Evidently, the extent of glycogen content reduction as is to be expected, is

in proportion with glycogen content in fresh muscles namely m. quadriceps femoris has the highest glycogen content and flank the lowest one.

The differences in the changes of pH values, glycogen content and free water content in samples thawed by microwaves and those thawed in the air indicate that glycolytic changes develop faster in samples thawed in the air. This may be due to the fact that, although microwaves are characterized by a high heat energy, the exposure to the waves is very short (only a few minutes) compared with the exposure to air at 22°C for 2-3 hours which has a favourable effect upon the development of the above biochemical changes.

Thawing time.- Time measurements of microwave thawing show that at constant irradiation conditions thawing time depends both on the intensity of the source of irradiation and the quantity and distribution of connective and fatty tissues. The mean values obtained (Table 2) indicate that there are time differences in thawing of tested samples of beef cuts.

The relationship between the thawing of beef cuts and the required time (Table 1) shows that increasing exponential functions are involved. The rate of thawing decreases between -1 and +1°C. The differences in required time for thawing various beef cuts, m. quadriceps femoris, neck and flank, are caused by differences in fatty and connective tissue content. The longest thawing period is in cuts interpenetrated with fatty tissue (neck) -5 minutes somewhat shorter in muscles with layers of fatty tissue (flank) -4 minutes



and the shortest in muscles with the lowest fatty tissue content (m. quadriceps femoris) -3 minutes. The fact that fatty tissue disperses and reflects centimeter waves is one of the principles of the mechanism of microwave spreading. This causes excessive surface heating and a very slight heating of deeper layers of the tissue. Therefore, a large part of microwave energy is needed for heating fatty tissue from which heat is transferred to the surrounding tissues, which implies indirect-secondary - heating of muscles. In meat pieces having a continuous layer of fatty tissue, there is a steady heat transfer to the surrounding tissues. This is the case even when the layer of fatty tissue is so thick as to cause total reflexion of microwaves. In contrast to this, in marbled meat pieces there is a much greater dispersion of microwave energy over a larger area. Therefore, thawing in the range  $-1$  and  $+1^{\circ}\text{C}$ , requires the longest time.

At the thawing moment, when the temperature reaches  $0$  to  $+1^{\circ}\text{C}$ , the moisture content of the tissue becomes higher which enables a better distribution and absorption of microwave energy. Since at  $+1^{\circ}\text{C}$ , the emission of microwaves is discontinued, the remaining part of the absorbed energy stimulates the development of biochemical processes in meat (Q-10). This may account for the significant differences in the pH values in cuts thawed in the air and those thawed by microwaves.

### CONCLUSIONS

1. Microwaves of 2840 MHz frequency and wavelength of 12.5 cm. can be employed for thawing beef cuts, exhibiting the force of 120 W/min.

2. The thawing operation by means of microwaves requires a few minutes and - with the conditions of irradiation kept constant - depends on the quantity and distribution of connective and fatty tissues.

3. The greatest energy consumption occurs in the rang  $-1$  and  $+1^{\circ}\text{C}$  which, at the constant emission of microwave energy, is manifested by the fact that longer thawing is required in that range.

4. Meat cuts thawed by microwaves have the colour of fresh meat; however, the surface brilliance is somewhat less intense. The colour of controls - cuts thawed in the air - is darker with a slight greyish shade.

5. Weight loss in samples thawed by microwaves is negligible in comparison with weight loss in samples thawed in the air.

6. The differences in the changes of the pH values, glycogen and free water content which occur in samples thawed by microwaves and those thawed in the air as compared with fresh meat indicate that glycolytic changes occur at a faster rate in samples thawed in the air.

## EFFECT OF MICROWAVES THAWING ON BEEF QUALITY

### Summary

A study on possibility of microwave application, as the heat source of high frequency, in thawing of beef cuts of different qualitative composition /without fatty tissue - m. quadriceps femoris, interpenetrated with fatty tissue - neck and muscle tissue with layers of fatty and connective tissues - flank/ indicated that for the purpose microwaves of 2840 MHz frequency, respectively of wavelength 12.5 cm and of 120 W/min. power, may be used. Microwave thawing lasts for several minutes and - at constant irradiation conditions - depends on quantity and distribution of fatty and connective tissues. The highest quantum of spent energy is in the range  $-1$  and  $+1^{\circ}\text{C}$  and at constant emission of microwave energy, it is manifested by longer thawing in the range.

The colour of meat pieces thawed by microwaves is as that of fresh meat; only the intensity of brilliance is somewhat lower. The colour of controls - pieces thawed in the air - is darker with scarcely remarkable greyish shade. The weight loss of samples thawed by microwaves is negligible in relation to the weight loss of samples thawed in the air. Differences in pH changes, glycogen content and free water content between samples thawed by microwaves and in the air in relation to the content of these components in fresh meat indicate faster development of glycolytic changes in samples thawed in the air.

# EFFET DE DEGEL PAR MICRO-ONDES SUR LA QUALITE DE LA VIANDE DE BOEUF

## Résumé

L'examen des possibilités de l'application des micro-ondes, en tant que source de chaleur à haute fréquence, sur le dégel des morceaux de viande de composition qualitativement différente (sans tissus adipeux - m. quadriceps femoris, entrelacé de tissus adipeux - cou, et muscles avec des couches de tissus adipeux et de ligaments - ventre) ont démontré qu'on peut se servir dans ce but des micro-ondes de la fréquence de 2840 MHz, c'est à dire d'une longueur d'onde de 12,5 cm. avec la force de 120 W/min. La durée du dégel par micro-ondes dure quelques minutes et - dans les conditions d'un rayonnement aux conditions constantes - dépend de la quantité et de la disposition des tissus adipeux et des ligaments. La plus grande consommation de l'énergie se situe dans la période entre  $-1^{\circ}$  et  $+1^{\circ}\text{C}$ , ce qui se manifeste dans les conditions de l'émission constante de l'énergie des micro-ondes par une durée plus longue du dégel à ce moment.

Les morceaux de viande dégelés par des micro-ondes ont la couleur de la viande fraîche, seule l'intensité du brillant de la surface est quelque peu réduite. La couleur des échantillons de contrôle - morceaux dégelés à l'air - est plus sombre avec une teinte grisâtre à peine sensible. La perte en poids des échantillons dégelés par des micro-ondes est négligeable en comparaison de la perte en poids des échantillons

dégelés à l'air. Les différences dans les changements des valeurs pH, du contenu en glicogène et en eau libre entre les échantillons dégelés par micro-ondes et à l'air, par rapport aux composantes dans la viande fraîche démontrent un processus plus rapide des changements glycolytiques dans les échantillons dégelés à l'air.

# ЭФФЕКТ МИКРОВОЛНОВОГО ДЕФРОСТИРОВАНИЯ НА КАЧЕСТВО ГОВЯЖЬЕГО МЯСА

## Р Е З Ю М Е

Исследования возможностей применения в качестве высокочастотного источника тепла микроволн для дефростирования кусков говядины различного качественного состава (без жировой ткани — quadriceps, пропитанного жировой тканью — шея и мышцы с отслоениями жировой ткани и соединительной ткани — пашина) показали, что с этой целью могут использоваться микроволны частотой в 2840 МГц, т.е. длиной волны в 12,5 см., мощностью в 120 Вт. в мин. Микроволновое оттаивание продолжается несколько минут и при постоянных условиях облучения зависит от количества и расположения жировой и соединительной ткани. Наибольшая масса энергии затрачивается между  $-1$  и  $+1^{\circ}\text{C}$ , что при константном излучении микроволновой энергии проявляется в более длительном времени дефростирования в этот период.

Куски дефростированные энергией микроволн сохраняют цвет свежего мяса, лишь интенсивность блеска поверхности несколько уменьшена. Цвет контрольных кусков дефростированных на воздухе темнее, с едва заметным сероватым нюансом. Потеря веса в кусках, дефростированных микроволнами незначительнее по отношению к потере веса кусков дефростированных на воздухе. Разница в изменениях pH, содержания гликогена и свободной воды между образцами дефростированных при помощи микроволн и на воздухе, по отношению к содержанию этих компонентов в свежем мясе, указывают на более быстрое протекание гликолитических изменений в образцах дефростированных на воздухе.

TOTAL AND FREE WATER CONTENT, pH AND GLYCOGEN CONTENT IN TESTED SAMPLES BEFORE AND AFTER THAWING

Table 1.

tested samples	total water (%)			free water (%)			pH value			glycogen (mg %)		
	FM	MWT	AT	FM	MWT	AT	FM	MWT	AT	FM	MWT	AT
m. quadriceps femoris	76,29	75,74	73,60	4,03	19,72	13,70	6,35	5,53	5,38	427	25	16
neck	75,41	75,03	73,10	3,35	19,08	15,46	6,32	5,64	5,61	242	19	15
flank	71,15	71,02	68,80	3,06	16,84	14,84	6,19	5,55	5,53	228	23	17
average values	72,28	73,93	71,83	3,48	18,54	14,55	6,28	5,59	5,50	299	22	16

FM = fresh meat

MWT = microwaves thawing

AT = air thawing

TEMPERATURE CHANGES IN TESTED BEEF CUTS DURING MICROWAVES  
THAWING

Table 2.

m. quadriceps		neck		flank	
Temperature (°C)	time (min.)	temperature (°C)	time (min.)	temperature (°C)	time (min.)
-8	0	-7	0	-7	0
-5	0 <sup>30</sup>	-5	1	-6	0 <sup>30</sup>
-4	0 <sup>40</sup>	-2	2	-5	1
-3	1	-1	3	-4	1 <sup>30</sup>
-2	1 <sup>30</sup>	0	5	-3	2 <sup>30</sup>
-1	2	+1	8	-2	4 <sup>30</sup>
0	3			0	6 <sup>30</sup>
+1	5			+1	8 <sup>30</sup>

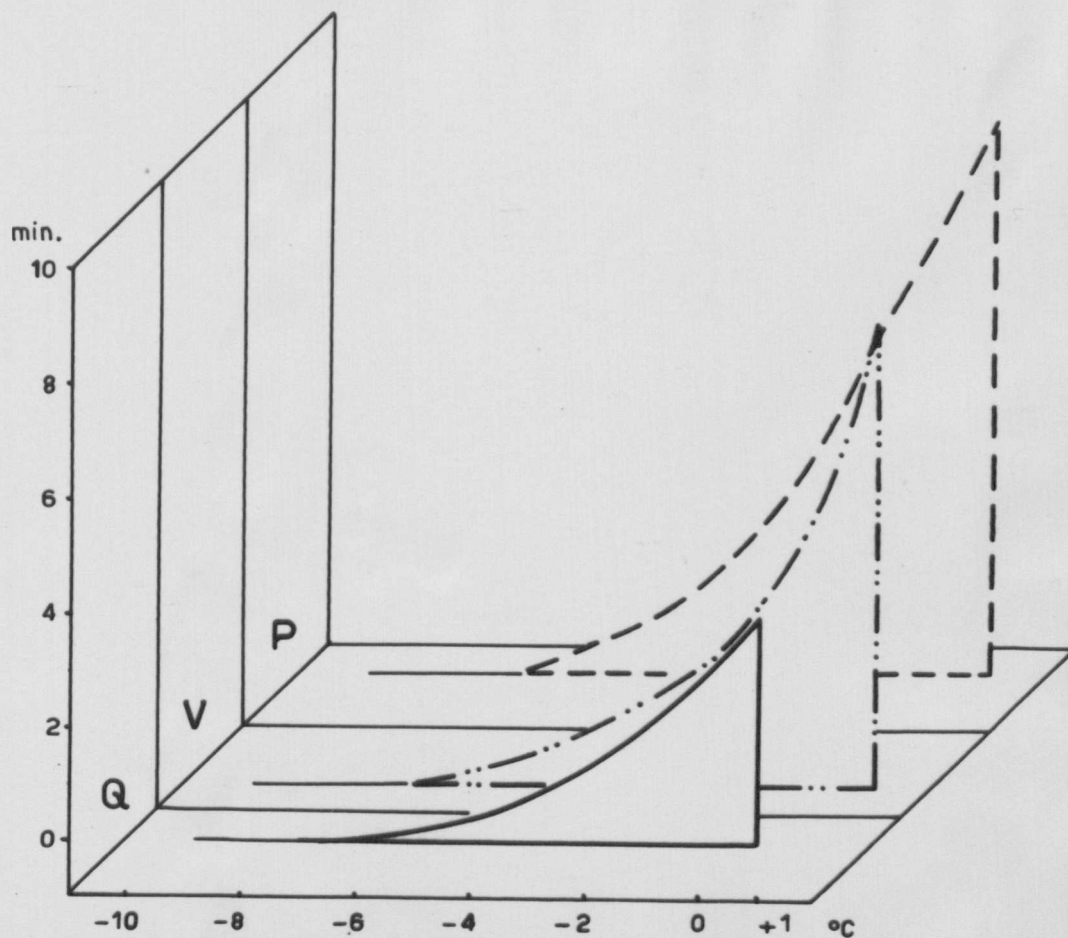


FIG. 1. TEMPERATURE CHANGES IN RELATION TO TIME  
DURING BEEF THAWING



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