Assessment of the processing of frozen meat in the production of meat products

Václav Pohůnek[1], Peter Hrubý[2], Rudolf Ševčík[1], Bronislav Smolka[1]

[1]Faculty of Food and Biochemical Technology
University of Chemistry and Technology in Prague
[2]FIMEX s.r.o.
Prague, Czech Republic

Abstract

An increasing pressure has been exerted on the food price by the distribution chains and consumers who still buy food primarily according to price, in recent years. On the other hand, we are also seeing increasing media campaigns for food of high quality. Producers are being forced to a greater or lesser extent, to process frozen meat due to pressures on product price and the lack of sufficient quantities of fresh chilled meat. If a company wants to consider buying the defrosting equipment for frozen pork or beef (which is frozen in blocks weighing 15, 20 or 25 kg) and needs to defrost 10 or 20 tons a day, it must reckon with the financial demands of this technological process. The costs of equipment of this type may be covered from the difference between the price of fresh chilled meat and frozen meat. This study compares the method of using radiofrequency defrosting with certain other methods that are still in use (defrosting chambers, microwave heating).

Meat defrosting, microwave heating, radiofrequency heating, thawing

Introduction

The aim of this paper is not to give a precise assessment of why is a frozen meat processed. The important thing is merely to define the fact that yields in the ready product are not exactly the same as in the processing of non-frozen material, though attempts are being made to come as close as possible to these yields with the use of new technologies. The method of freezing has a fundamental effect on yield. If the meat producer proceeded in the correct manner, the meat was carefully frozen in a sufficiently rapid manner. Than the greatest possible number of small crystals, that do not cause any great damage to the cells of the muscle tissue, are formed in the meat during freezing. The producer must also be sure that the processed material to be defrost was not exposed to a high temperature for a crucial period of time during subsequent handling, and that the temperature was always lower than minus 18 °C and did not fluctuate. If such errors occurred, there may be a risk of enzymatic and microbial changes or the recrystallisation of ice (the formation of large crystals). All these changes may cause significant damage to the texture of the final products and make a fundamental contribution to reducing yield. Meat must be defrosted in such a way as to minimise the risk of spoilage and creation of toxins in foodstuffs. During defrosting, the food must be exposed to the conditions (temperature and period of defrosting) that do not lead to any risk to health of consumers or any reduction to the material quality. The defrosting process affects the quality of foodstuffs just as much as the method of freezing and the conditions of freezer storage. It is essential to defrost such material in such a way as to minimise any loss of liquid – in meat, this means drip loss and evaporation loss which may amount to as much as 30%. In addition to these losses, any juice released is a suitable environment for undesirable enzymatic and, most importantly, microbiological processes (Kadlec 2012).

It is essential to know what is the given material intended for, e.g. whether it is to be injected and individual cuts of meat used for all-muscle products such as smoked meats, or whether it is to be used for comminuted products. Comminution is an operation that does

Address for correspondence:
Ing. Václav Pohůnek
Faculty of Food and Biochemical Technology
University of Chemistry and Technology in Prague
Technická 5, 166 28 Praha 6 – Dejvice, Czech Republic
Phone: +420 220 443 013
E-mail: vaclav.pohunek@vscht.cz
www.maso-international.cz

not demand complete defrosting. Today's meat processing machinery can handle blocks of meat with sub-zero internal temperatures. This technology is ideal from the viewpoint of maximum advantage being made of the binding capacity of the meat. A band of temperatures from minus two to minus half a degree Celsius must be exceeded for injected products. This operation requires the delivery of a significant amount of energy and also extends the defrosting period due to the so-called latent heat. Three defrosting systems are used in practice for defrosting blocks of meat – defrosting chambers, microwave tempering and radiofrequency defrosting (Leygonie et al. 2012).

Defrosting chambers

Defrosting chambers with trolleys for handling defrosted meat are used most often today for defrosting. Placing individual blocks of frozen meat in trolley frames is a time-consuming and physically demanding process. The chamber fans send a mixture of tempered air and steam, usually of a temperature between +3 °C and -3 °C, into the chamber space. The current of air and steam is directed by a positionable structure, usually guide plates. The airflow speed in the chamber ranges from 0.5 to 5 $m \cdot s^{-1}$. The steam forced into the chamber attaches to the meat and prevents losses. If the meat is already packaged, steam is used not to prevent losses but to ensure improved heat transmission. The main disadvantage is the fact that it is a time-consuming operation. The risk of the multiplication of microorganisms and, thereby, spoilage is increased during a long period of defrosting. Greater drip losses are also seen during a long period of defrosting. Unpacked meat may be contaminated by steam; in this case air and steam must be forced into the defrosting chamber through filtration units that remove possible microorganisms from the mixture. The use of chambers for defrosting and subsequent production of smoked meats (all-muscle products), for example, is both time-consuming and costly. The purchase costs of defrosting chambers are low in comparison with other types of defrosting equipment, though a number of these chambers are required for defrosting sufficiently large volumes of meat to ensure the uninterrupted processing of frozen materials (Pham et al. 1993; Brown and James 2006).

Microwave tempering

Microwave tempering has also been used for meat in recent decades. Caution must be taken with the use of microwave tempering. The surface of a block of meat may often be overheated by microwaves which may have a concentrated effect and may have a different effect on each meat component. The concentrated action of microwaves may result in local heating and, thereby, the denaturing of proteins which may reduce the binding capacity of the meat. Microwave heating constructions that eliminate these negative effects and that are suitable for more precise meat tempering have begun to be applied in practice. The construction of functional areas and the parameters of microwave diffusers are also of considerable importance. Microwave heating can be used, for example, for heating the surfaces of blocks of meat for easier and loss-free removal of protective films. It is also applied in the tempering of comminuted meat, achieving homogeneity of water and fat and uniform heating. This kind of heating is also suitable for blocks of meat that are to be processed into comminuted meat products, in which case tempering ends within a range of temperatures of -2 °C to -4 °C. The depth of penetration of microwaves into the meat is often a limiting factor in the use of microwave heating. A tempering depth of 6 cm is given as a limit value which corresponds to a frozen block of a maximum height of 12 cm. Microwave tempering is unsuitable for meat destined for tumbling and injection in view of impaired binding capacity and, most importantly, the reduced penetration of microwaves into the centre of the block of meat. Entirely defrosted meat is required for these types of further processing. Speed and performance are advantages of microwave tempering. Performance is dependent on the volume and thickness of the blocks of meat. Its disadvantages are the purchase costs involved, a certain discontinuity in the production process and the external security of microwave chambers (He et al. 2014).

Radiofrequency defrosting

The principal advantage of a radiofrequency defrosting system over traditional systems (tempering in air) is the fact that defrosting is performed in a matter of minutes rather than hours or days, even for large blocks of products. Material can be defrosted by radiofrequency defrosting in its storage packaging (cardboard boxes, polyethylene film, etc.). Another advantage of radiofrequency tempering is the fact that it uses energy only when the frozen blocks are located in the space beneath the electrodes (Fig. 1).

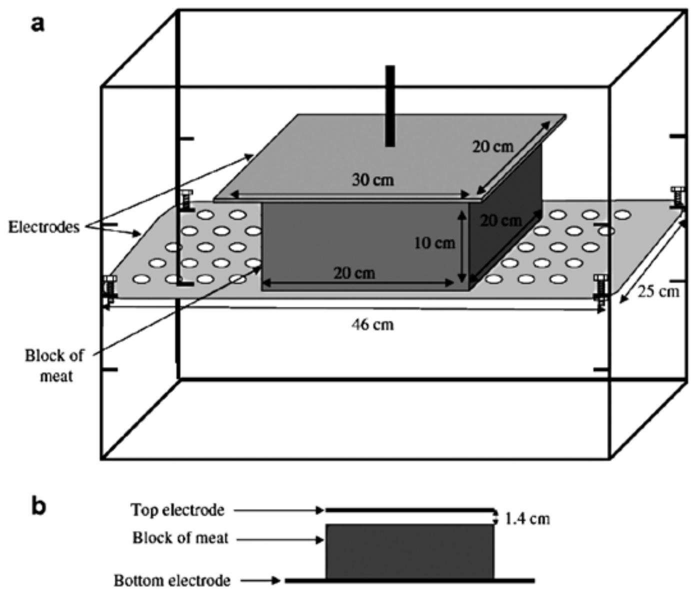

Fig. 1. Connection of electrodes and product placement in radiofrequency equipment (a), side view of the placement of electrodes and the product (b) (Farag et al. 2009)

The speed and uniformity of defrosting minimise any local denaturing of proteins and product degradation. This method also results in minimal drip losses, any worsening of organoleptic, chemical and physical properties is minimal, and microbial growth is reduced. The entire process can be set to a continual mode which also improves further processing. Radiofrequency equipment requires less floor-space than the traditional method of defrosting in defrosting chambers. The disadvantage of radiofrequency tempering is the resultant temperature of the product which cannot be entirely defrosted using this method. Such meat cannot be injected, tumbled or marinated. Radiofrequency tempering serves to increase the temperature (for example from -25 °C to a final temperature just below 0 °C). Another method of defrosting must then be used to achieve temperatures above 0 °C. The times required for tempering meat by radiofrequency tempering are given in Table 1. A time ranging from 10 to 25 minutes is required for defrosting from freezing temperatures of -20 / -18 °C to a final temperature in a range of -6 to -1 °C depending on the type of product, fat content and method of packaging. There are no limitations to the system of radiofrequency heating for all types of applications requiring cutting, comminuting or slicing after tempering. Radiofrequency tempering must be complemented by a suitable system of complete defrosting (in a defrosting tumbling device, for instance) when temperatures above 0 °C are required (i.e. for injecting, tumbling, marinating, etc.).

Table 1. Time required for radiofrequency tempering of various types of production meat and packaging (http://www.stalam.com)

Product	Weight and type of packaging	Temperature increase		Period of tempering [min]
		Initial temperature	Final temperature	
Beef trimmings (7% fat)	20 kg block	-18 °C	-3/0 °C	25
Beef trimmings (15% fat)	20 kg block	-18 °C	-4/0 °C	25
Shoulder of pork	20 kg block	-12 °C	-4/-1 °C	18
Pork (20% fat)	16 kg vacuum-packed block	-12 °C	-4/-1 °C	18
Beef	25 kg block	-20 °C	-8/-6 °C	20
		-20 °C	-4/-2 °C	35
Whole chicken	10 kg cardboard box	-18 °C	-2/0 °C	30
Chicken leg	10 kg cardboard box	-18 °C	-2/+2 °C	30
Chicken breast fillets	10 kg cardboard box	-18 °C	-3/0 °C	30
Beef kidneys	23 kg block	-18 °C	-4/-1 °C	30
Beef tongue	2.2 kg vacuum-packed bag	-18 °C	-3/0 °C	20
Pork tenderloin	20 kg block	-20 °C	-2/0 °C	30
Pork loin	10 kg vacuum-packed bag	-20 °C	-5/-2 °C	20
Pork trimmings (72% lean)	27 kg block	-18 °C	-2/0 °C	40
		-18 °C	-4/-2 °C	20
Skinned side of pork	5 kg block	-18 °C	-4/-2 °C	15
Beef trimmings (95% lean)	20 kg block	-18 °C	-4/-2 °C	30
Beef trimmings (90% lean)	20 kg block	-18 °C	-3/0 °C	40
Beef trimmings (70 – 85% lean)	15 kg block	-18 °C	-7/-4 °C	12
Boned shoulder of pork	27 kg block	-18 °C	-4/-1 °C	40
Pork trimmings	17 kg block	-10 °C	-3/-1 °C	10
Leg of pork	20 kg block	-10 °C	-3/-1 °C	10
Lean pork ham	20 kg block	-13 °C	-1/0 °C	40
Pig trotters	20 kg block	-13 °C	-1/0 °C	40
Shoulder of pork	20 kg block	-18 °C	-3/-1 °C	40
	25 kg block	-18 °C	-4/-2 °C	25
Turkey	10 kg block, plastic crate	-18 °C	-4/-2 °C	20
Chicken trimmings	10 kg block	-18 °C	-3/0 °C	40
		-18 °C	-5/-3 °C	20
Turkey breast	18 – 22 kg blocks, plastic crates	-18 °C	-5/-2 °C	20
Chicken breast	15 – 18 kg blocks, plastic crates	-18 °C	-5/-3 °C	30
Chicken wings	10 kg cardboard box	-18 °C	-3/-1 °C	25
Chicken fillets	7.5 kg plastic bag	-18 °C	-2/0 °C	15
Mechanically-separated chicken meat (20% fat)	12.5 kg plastic bag	-18 °C	-2/-1 °C	10

In such cases, the principal advantage of radiofrequency tempering lies in speeding up the entire process and reducing the overall drip loss (Farag et al. 2008; Farag 2009).

Processing partially tempered meat

Equipment that tumbles meat during defrosting can be used to defrost meat that has been tempered to temperatures beneath 0 °C. One example is the “Magnum Cool Defro” defrosting and tumbling device (Inject Star Pökelmaschinen Gesellschaft m.b.H.). This model has double walls between which a heat-transfer medium flows at a temperature of 40 – 60 °C. The entire system works in a vacuum. The period of the defrosting cycle (6 – 12 hours) is dependent on the temperature of the input material and the temperature of the heat-transfer medium to guarantee the most considerate defrosting process. The lower the defrosting temperature selected, the higher the quality of the meat exiting the device. The tumbling process guarantees extremely low (practically zero) drip loss, with the exudate being tumbled back into the meat during the process. The device is switched automatically to cooling when meat internal temperature of 0 °C to +1 °C is attained. Brine may be added during tumbling depending on the subsequent processing of the product (www.injectstar.com).

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