Drying and ripening – a basic processes in the production of dry-cured products

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review

Summary

Drying is probably one of the oldest methods of meat preservation. The result of the drying cycle is primarily water loss (dehydration and evaporation), which manifests itself as a weight loss of the product. Reducing the water content in the product decreases the activity of microorganisms, and therefore prolongs the shelf life of products. The fundamental change underlying the protection against spoilage is lowering the water activity of the product (aw), which is determined by joint action of the water content, soluble substances and substances which are capable of swelling. Increasing in the proportion of soluble substances in meat, reduces the required level of drying. Therefore, to achieve the desired level of aw of products, drying is always combined with other methods of preservation (salting, smoking). Furthermore, the pH value of the product affects the target aw value (impact on the ability of meat proteins to bind water) in a way that lower pH values provide higher aw values. The rate of drying of meat products depends mainly on three factors: surface drying, the difference between aw and relative humidity (drying driving force) and the properties of the outer layers of the product. Preserving the difference between aw and the relative humidity, which is achieved by regulating the speed of air flow and air temperature, maintains the drying driving force. Gradual migration of water from inner parts of the meat to the surface, the simultaneous diffusion of salts and other dissolved brine ingredients within the product and reducing aw, up with the bacteriostatic effect of salt, creates unfavorable conditions for microbial growth, which is very important for the product shelf life. Numerous chemical reactions in the process of drying and ripening of dry-cured products (enzymatic hydrolysis, oxidation, etc.) in which a vast number of different chemical compounds occurs (non-volatile and volatile), are responsible for the generation of desirable sensory properties of products, primarily flavor and aroma.

Keywords: *drying, ripening, water activity, dry-cured meat products*

Introduction

Drying, along with heat treatment, is probably one of the oldest ways of meat preservation. In contrast to the chilling and freezing, which were once applied only seasonally or in the areas of polar climate, drying as such or in combination with smoking may be applied in all parts of the world. This method by which the meat is preserved for later use, was of vital importance to humans at the time when hunting and fishing were not always successful, or when the meat of large animals was too much to be eaten in the short period of time (Zukál and Incze, 2010).

With the development and progress of society in general, the process of meat drying was also improved. Unlike today's modern industrial chambers for meat drying, the beginnings of organized production of dried meat were related to the drying rooms with large doors and windows in which the air flow (as well as temperature and air humidity) were regulated by their opening and closing, depending on outer temperature and air humidity. Dehydration of the product was checked by touch, and on the basis of color, shape and elasticity of the product, which required a great experience, despite not always secure success. The modern drying chambers for the meat products have fully automated and controlled microclimate, and product quality is tested by various instrumental and subjective methods.

The main result of the drying process of meat products is water loss (dehydration and evaporation) which decreases the activity of microorganisms, and thus extends the shelf life of products. Furthermore, the mass and volume of products are reduced, facilitating the manipulation. The texture of the product becomes harder, and flavor stronger, especially in the products with longer ripening stage (Ramirez-Ruiz et al., 2005a).

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Correlation of the drying process and water activity (a_w) in the product

Protection against spoilage as a result of the drying process is based on the decreasing of water content in the product, or reducing the water activity (a_w). Water activity is basically the ratio, expressed numerically, between the water pressure above the material (p) and vapor pressure over pure water (p_0) at the same temperature ($a_w = p/p_0$). Water vapor pressure in a thin layer around the product (so-called laminar layer) is constant and equal or lower than the vapor pressure over pure water. Microorganisms cannot grow in a medium which is under their specific a_w (Table 1) (Zukál and Incze, 2010).

Inhibition of growth of microorganisms present can be achieved by decreasing a_w of the product to the lower a_w range for each microbial species. During drying, stated decreasing of a_w is achieved by dehydration, or lowering the water content in the product. In addition it is necessary to know the relationship between the content (relative humidity) and water activity (a_w). This relationship is essentially complicated, because it is different for specific media. There are two types of substances that are able to reduce the water activity in some media. These substances are substances soluble in water and substances that swell in water (in the meat these are structural proteins). For meat products is important the first type, and for the meat dishes the second type. For a better understanding should be emphasized that tissues entering into the composition of meat, except of muscular, have no effect on a_w of meat (eg adipose tissue). This means that a_w does not depend on water content in that media, but on the relationship of water to the ingredients that affect it. Thus, raw adipose tissue has a_w about 1, regardless of the low water content (Zukál and Incze, 2010).

Table 1 **The lower a w range of development of microorganisms (Zukál and Incze, 2010)**

Bacteria	Yeasts	Moulds	a_w
Escherichia coli			0,99
Streptococcus fecalis			0,98
Vibrio metschnikovii			0,97
Pseudomonas fluorescens			0,97
Clostriduim botulinum			0,97
Campylobacter ssp.			0,97
Shighella			0,97
Yersinia enterocolitica			0,97
Cl. perfrigens			0,96
Bacillus cereus			0,96
Bacillus subtilis			0,95
Samonella Newport			0,95
Enterobacter aerogenes			0,94
Microbacterium			0,94
Vibrio parahaemolyticus			0,94
Lactobacillus vridescens	Schizosaccharomyces	Rhisopus	0,93
		Mucor	0,93
	Rodotorula		0,92
Micobacterium roseus	Pichia		0,91
Anaer. Staphylococus			0,91
Lactobacillus	Saccharomyces		0,90
Pediococcus	Hansenula		0,90
	Candida	Asp. Niger	0,88
		Debaryomices	0,88
	Torulopsis	Cladosporium	0,87
Staphylococus aureus	Torulaspora	Paecilomyces	0,86
Listeria monocitogenes			0,83
		Penicillium	0,80
		Asp. Ochraceus	0,80
Halofilne bakterije			0,75
		Asp. Glaucus	0,72
		Chrysosporiumfastidum	0,70
Zygosaccharomyces rouxii		Monascusbisporus	0,60

In the processing of meat, the goal is to reduce a_w to the desired level, which depends on the temperature at which the product will be stored (storage temperature). Dry-cured meat products should not be kept in conditions of lower temperatures; they can be stored at room temperature due to low a_w. The pH value of the product also affects the target a_w; a lower pH value allow higher a_w values i.e. the range that assures the hygienic safety of products is a function of pH and is inversely proportional to the range of pH.

Traditional meat products usually have a pH of about 6.0, what for food safety issues requires lowering of a_w under 0.9, while for fermented products that have a pH of about 5.0 is sufficient to lower a_w below 0.95 (Incze, 2004).

Water activity of a medium is determined by the joint action of three factors: water content, soluble solids content and the content of substances that are capable of swelling, while the other ingredients in the investigated medium have no effect on a_w. Smaller water quantities meat proteins bind independently of a_w, while the remaining water is bound as a_w grows. Simultaneously, the amount of bound water depends on the state of particles that are capable of swelling (denaturation). Fresh meat (no visible fat) contains about 80% of water, 19% of proteins (that are capable of swelling) and 1% of soluble solids (Zukál and Incze, 2010). From previous research we could draw parallel between the water content (%) and water activity in the product (a_w), where it can be concluded that the water content in raw meat must be reduced to the at least 40% to achieve a_w of 0.90 (Lewicki, 2004, Ramirez-Ruiz et al., 2005). This means that the weight loss in the meat processing should be about 60%, which requires high costs, particularly for energy. In addition, this product has too hard texture, and it is necessary to be soaked in water to become edible. Therefore, the process of drying of meat products must be combined with some other method of preservation or several of them (usually salting or brining and smoking), that acting together lower the a_w of the product to the desired level. Increasing the proportion of soluble substances in meat, reduces the required degree of drying, i.e. by the same degree of drying the lower a_w is achieved. The use of salt (and sugar) in the meat processing particularly effects the sensory properties of the product, but its conservative effect has great importance and manifests itself exactly in the reduction of product a_w. Due to lower mass of salt particles in relation to the particles of sugar, the same effect on reducing a_w of meat can be achieved by the addition of much less salt than sugar, so the effect of sugar in this sense is not considered significant, given the small amounts used in the manufacture of some meat products. The importance of sugar in this regard is in the production of fruit products and confectionery. The Na^+ i Cl^- ions bind approximately two molecules of water in solution, thus NaCl reduces a_w (Zukál i Incze, 2010). Saturated NaCl solution contains 26.5% of NaCl (a_w = 0.75), while the content of NaCl in meat products is significantly lower. A piece of raw of meat without visible fat must contain at least 6.6% of NaCl in order to reach a_w of 0.95. Such a product due to excessive salinity is not good for consumption, but the addition of adipose tissues can reduce salinity, what along with other methods and used in the production of meat products (Gou et al., 2004). Another method for reduction of salinity of the end product is the addition of small amounts of salt in the beginning, and then drying to achieve the target a_w, where the salinity of the end product will be lower due to higher proportion of proteins and fats in relation to the initial product. This method is the basis for in the production of dry-cured and semi-cured meat product (Zukál and Incze, 2010). Furthermore, an additional positive effect of salting is the impact of salt on the swelling of meat, salt thus indirectly affects the texture of the products that are easier to slice and become softer and more soluble when chewing, which are very important sensory properties of dried meat products (Ruiz-Ramirez i sur., 2005a).

When planning the necessary degree of drying, i.e. reduction of product a_w, it is necessary to bear in mind the properties of raw materials and final product (water content, content of proteins, salts and other soluble and insoluble substances, sensory properties) and the a_w of the final product to be reach in order to achieve the desired properties (Zukál and Incze, 2010). Water activity in meat, that is necessary for achieving food safety, as already stated, depends on the pH. As pH value of the product is higher, w_a must be lower (Ramirez-Ruiz et al., 2005a). Weight loss and the initial amount of added salt can be calculated on the basis of stated desired properties of the final product. The next task is to determine the drying rate, which requires a good understanding of process itself. Schematic diagram of the physical and chemical changes in meat products during the processing, and thus the drying stage is shown in Figure 1. During the drying stage the composition of the surface layer of the product is changed as a result of evaporation of surface water vapor. Water from the next layer by diffusion exceeds in the surface layer, and the process continues until the deepest central parts. At the same time different substances (meat ingredients or added ingredients) pass from one layer of the product to another. Thickness, and possibly the shape of individual layers of product, changes, as well as mechanical and sensory properties which become improved (Zukál and Incze, 2010). The condition for the evaporation of surface water vapor is higher a_w of the surface layer with respect to the relative air humidity around the product. Otherwise comes to water binding to the surface layer, which thus becomes wet. Drying rate of meat products depends mostly on three factors: surface drying, the difference between the a_w and relative air humidity (drying driving force) and the properties of the product surface layer (eg, types of sausage casing, the presence of mold, the level of resistance to drying of the surface layer). Surface drying is in fact the geometric surface of the product when taking into account the ratio of part which is permeable to water (meat) and the total area of the product. Surface drying of ham with the skin is significantly smaller than its actual surface of, because dehydration is achieved only through the "open" surface of the leg, given that the surface of the skin is insulated with a layer of subcutaneous adipose tissues and skin (Zukál and Incze, 2010). This "barrier effect" is also used in the manufacture of some types of ham, where the "open" surface of the leg is, in a particular production stage, overcoated with a mixture of fat and other ingredients, which slows dehydration and contributes to the creation of special flavor in an extended process of maturation (Andrés et al. 2007).

Surface of product is constantly reducing during drying, especially more permeable parts, which slows drying. Water vapor that evaporates from the surface increases air humidity around the product, and as evaporation lowers the temperature of the surface layer of the product and of the ambient air, relative humidity is further increased. To maintain the drying driving force, it is necessary to lower the relative humidity and ambient air temperature. This is achieved by accelerating air circulation thereby reducing the surface resistance of the product to the drying, which besides depends on the porous of casing, the presence of mold and the thickness of adipose tissues (or coating) on the surface. With the progress of the drying process, the resistance is growing steadily, reducing the rate drying (Zukál and Incze, 2010).

Loss of water in the surface layer of the of product causes an increase in the salt concentration in it, which then diffuses into the deeper layers reducing its concentration in the surface layer. The driving force of diffusion is different for the salt content in comparison with the water content. It seems that the diffusion of salt is faster because the salt concentration in the surface layer is in the greater equilibrium than the water concentration. Thus, the salt content in comparison with the mass of water is lower in the outer layers of the product (Gou et al., 2004). In the initial phase of drying the water content decreases in the surface layers, while the deeper layers loose water in the later phases of drying. The process of balancing the water content becomes slower with the progress of drying, which also slows the flow of drying. At the end of the drying process the water content in certain layers of the product almost does not change.

The gradual loss of water during the drying process is the result of the simultaneous transfer of heat by the air flow to the product and of water evaporation in the opposite direction. Gradual migration of water from inner parts of the meat to the surface, the simultaneous diffusion of salts and other dissolved brine ingredients within the product and reducing meat a_w, up with the bacteriostatic effect of salt, creates unfavorable conditions for microbial growth, which is very important for the product shelf life. Water loss from inner and outer parts is moving at different tempo. The inner layers of the muscles more slowly loose water, but the tempo is more equalized before the end of processing. In addition, water content and a_w of product depend on many other factors (type, size and shape of product, meat quality, salt content, microclimate conditions, etc.). The fact is that the diffusion and evaporation of water is very complex and slow process, and is most intensive in drying and ripening stages of the processing. When the average concentration gradient is reached, diffusion of water takes place under the so-called Fick law (the flow of the substance that diffuses is proportional to the concentration gradient), in accordance with the following formula (Toldrá, 2002):

$$(X - X_0) = D\,(C - C_0)$$

where:

X - distance (m);

C - moisture content (kg/m^3);

D - diffusion coefficient (m^2/s)

Diffusion coefficient (D) cannot be taken as constant due to the high variability caused by various conditions, the tissue properties of cured meat product (muscle composition, fiber direction in relation to the movement of water), technological processes (salting, drying), etc. In most cases, the estimate of the diffusion coefficient (D_e) should be done. Gou i Comaposada (1997) i Gou i sur. (2002) examined the influence of meat pH and direction of muscle fibers on the diffusion of water in ham. The value of D_e at 5°C and10% of salt, for the muscular fibers which are transverse with respect to the direction of movement of water is 3,07 x 10^{-11} m^2/s, and for the fibers of parallel direction 6,11 x 10^{-11} m^2/s (Gou i Comaposada, 1997). The value of D_e for the muscle fibers that are perpendicular to the (Gou i sur., 2002). A number of factors affect the diffusion of water toward the product surface, such as pH (low pH favors the loss of water) and the presence of intramuscular fat, which prevents the diffusion of water by creating a physical barrier. Greater product weight (and smaller size) also extends the time required to achieve the desired percentage of water in the product.

Sensory properties of the final product that are related to the texture, such as softness when chewing, ease of slicing, proper hardness and elasticity are very important from the standpoint of quality dry-cured meat products, and are directly associated with the process of drying and dehydration. During drying, the initial plasticity of raw materials loses, and stated texture properties are improved. The surface layer of the product, due to higher dry matter content, is harder than the inner layers (Ramirez-Ruiz et al., 2005a). Too low water content in the over-dried products causes the denaturation of proteins and proteins lose the ability to swell, which directly affects almost all texture properties of products. Loss of volume of the product during drying causes an increase in strength of the outer layers, which at first consequently loses plasticity, and then the elasticity. Too fast drying causes denaturation of proteins in the surface layer which becomes irreversibly hard, i.e. a hard surface crust is created, which prevents further shrinkage of that layer that should happen in the following phases of drying. Therefore, the surface layer is separated from the inner, thus causing the creation of cavities, voids and cracks through which air reaches the inner layers of the product (Zukál and Incze, 2010). The presence of oxygen in the inner (deeper) layers, except for allowing the growth of aerobic microorganisms, contributes to the occurrence of rancidity (lipid oxidation), spoilage and creating of a bad smell. Therefore, the meat products must be dried slowly to avoid the crust creation. In one-piece meat products, that always have adipose tissue sections besides the muscle, these defects occur much less frequently. Furthermore, as a result of enzymatic degradation of proteins, the meat becomes softer with the progress of the drying and ripening processes (Toldrá, 2006), and additionally an optimum texture of the product can be achieved by applying a mild heat treatment (below 50°C) at the end of the drying process (Morales et al., 2008).

Physico-chemical changes in product tissues formed during the drying and ripening

Most of physical changes occurring in cured meat products during processing (salting, drying, ripening) are described in above text, and schematic diagram together with the chemical changes that occur at the same time as the physical, moreover, they are interrelated in a way that one causes the other, is shown in Figure 1. Technology of dry-cured meat products, no matter what type of product involved is based essentially on the methods of salting, drying and ripening of the product. So far, numerous studies have been conducted on the changes that occur in the tissues during processing of meat products, especially of different types of ham. It is known that the desirable sensory properties of ham

Table 2. **Brief description of main substrates and products for most important muscle proteolytic and lipolytic enzymes. (Toldrà, 2007)**

Enzymes	Main Substrate	Main Product
Cathepsins	Myofibrillar proteins	Protein fragments
Calpains	Myofibrillar proteins	Protein fragments
20S proteasome	Myofibrillar proteins	Protein fragments
Tripeptidylpeptidases	Polypeptides	Tripeptides
Dipeptidylpeptidases	Polypeptides	Dipeptides
Dipeptidases	Dipeptides	Free amino acids
Aminopeptidases	Peptides (amino termini)	Free amino acids
Carboxypeptidases	Peptides (carboxy termini)	Free amino acids
Lysosomal acid lipase	Triacylglycerols	Free fatty acids
Acid phospholipase	Phospholipids	Free fatty acids
Esterases	Triacylglycerols	Short chain free fatty acids
Hormone sensitive lipase	Triacylglycerols	Free fatty acids
Monoacylglycerol lipase	Monoacylglycerols	Free fatty acids

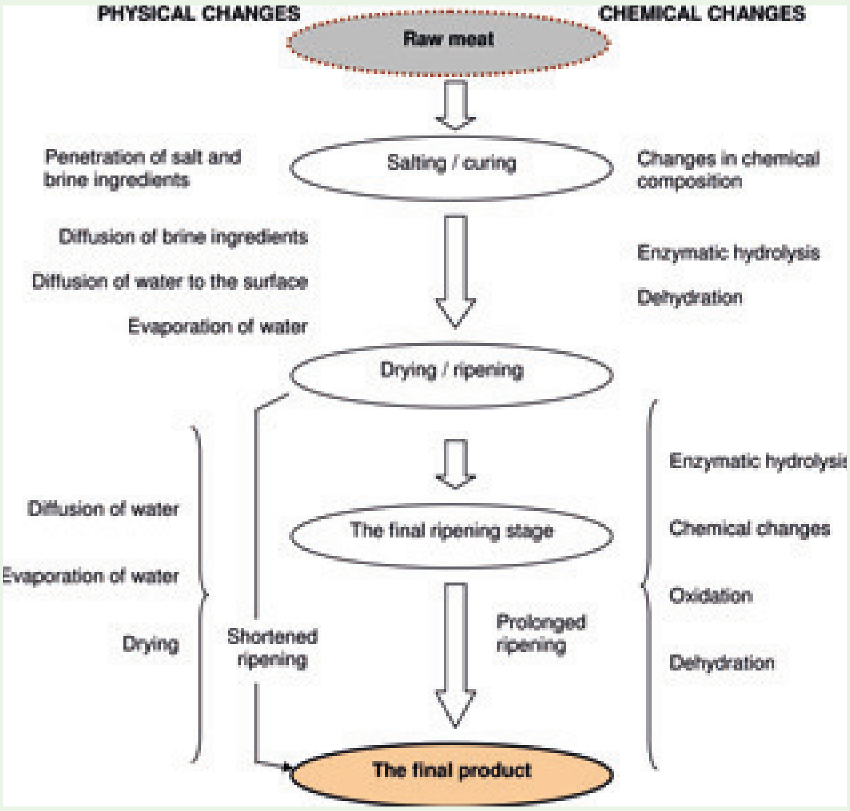

Figure 1 **Physical and chemical changes of meat during salting, drying and ripening processes Source: Krvavica, 2012, quote: Toldrá, 2002)**

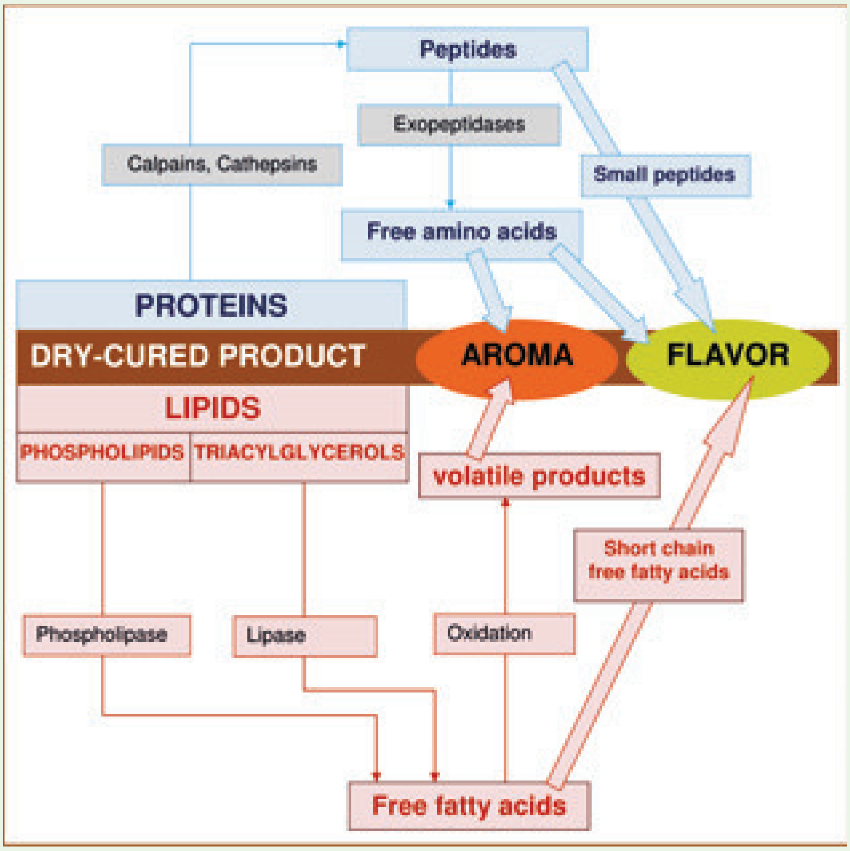

Figure 2 **Proteolysis and lipolysis - generators of flavor and aroma components of dry-cured products**

generate along the process of maturation as a result of complex chemical processes, particularly decomposition of proteins and fats in the leg tissues, in the reactions of proteolysis and lipolysis (Toldrá, 2002). Numerous chemical reactions involving enzymes, mainly endogenous (Table 2), lipid oxidation, Maillard reaction, Strecker degradation, and many others in which a vast number of different chemical compounds (non-volatile and volatile) are generated, are responsible for the creation of desirable sensory properties, above all flavors and aromas (Toldrá, 2002). However, the foundation of dry-cured meat products quality is contained in the raw material and technology that is applied during processing, and knowledge and understanding of a complex system of chemical reactions in the tissues of these products contribute to establishing better control of processing and final product quality.

Proteolysis is a series of complex biochemical reactions that comprise primarily hydrolysis of myofibrillar and sarcoplasmic proteins during ripening of cured meat products (Figure 2). Proteolytic activity is the main feature of the endogenous enzyme systems in tissues of meat products. They, along with limiting factors (pH, a_w, salt concentration, etc.), create unfavorable conditions for microbial growth, so the activity of microbial enzymes within these products is almost negligible (Toldrá and Molina, 1992), with the exception of sausages from a group of durable fermented products.

The importance of proteolysis, in terms of product quality, manifests in several ways. Proteolysis is directly involved in the formation of product texture on the basis of degradation of myofibrillar proteins that build muscle structure. Generated peptides and free amino acids affect the flavor, and free amino acids participate, as substrates, in future reactions that contribute to the final formation of aroma and flavor. This is especially characteristic for the products that have longer ripening stage (eg, ham). Small peptides, for various combinations of amino acids of which they consist (mostly di-and tri-peptide), have a significant impact on the sensory properties, especially flavor and aroma, although for some of them (eg, carnosine, anserine) is determined to have antioxidant effects (Lynch and Kerry, 2000), and some other (opiates, prebiotics, antihypertensive agents, immunomodulators, antibiotics, etc.) biologically active properties (Keizo, 2006). Most former studies were focused on muscle enzyme systems, in order to account for changes occurring during processing, as well as establish better control of processing and thus optimize product quality (Nolet i Toldrá, 2006).

The course of proteolysis can vary greatly depending on the type of product, quantity of endogenous proteolytic enzymes and specific processing conditions (Sarraga et al., 1993; Toldrá and Flores, 1998; Toldrá, 2002, Krvavica and Đugum, 2007). Degradation begins by activity of endogenous enzyme calpain and cathepsin on foremost myofibrillar proteins, forming protein residues and polypeptides of medium size, what is essentially a result of hydrolysis, i.e. degradation of the structure of the Z-membrane and of proteins troponin T, desmin, nebulin and titin, and sarcoplasmic proteins (Toldrá, 2002). Polypeptide degradation continues to small peptides, as a result of dipeptidylpeptidases and tripeptidylpeptidases activity. Finally, free amino acids are a result of dipeptidase, aminopeptidase and carboxypeptidase activity. The activity of enzymes of microbial origin is also present, albeit in a durable one-piece meat products is not very

Trocknen und Reifen – technologische Grundprozesse bei der Herstellung der getrockneten Fleisch-Dauererzeugnisse

Zusammenfassung

Das Trocknen ist wahrscheinlich die älteste Art der Fleischkonservierung. Das Resultat des Verfahrens ist in erster Linie der Wasserverlust (Dehydration und Evaporation), die sich als Schwund der Erzeugnissmasse (Kalo) demonstriert. Durch die Verminderung der Wassermenge in den Erzeugnissen wird die Aktivität der Mikroorganismen vermindert, und somit auch die Gültigkeitsdauer des Erzeugnisses verlängert. Die Grundveränderung, auf der der Verderbensschutz basiert, ist die Verminderung der Wasseraktivität im Erzeugnis (aw), die durch die gemeinsame Wirkung des Wassergehaltes, der auflösbaren Stoffe und der Stoffe, die aufquellen können, bestimmt ist. Durch die Anteilvergrößerung der auflösbaren Stoffe im Fleisch, wird das nötige Trockenenniveau vermindert. Deshalb wird zur Erreichung des gewünschten Niveaus von aw des Erzeugnisses, das Trocknen immer mit anderen Konservierungsverfahren kombiniert (Salzen, Räuchern). Weiters beeinflusst der pH Wert des Erzeugnisses die gezielte aw (Einfluss auf die Fähigkeit der Eiweißstoffe des Fleisches, Wasser an sich zu binden), und zwar so, dass niedrige pH Werte höhere aw Werte ermöglichen. Die Schnelligkeit des Trocknens von Fleischerzeugnissen hängt hauptsächlich von drei Faktoren ab: Trocknenfläche, Unterschiede zwischen aw und relativer Luftfeuchtigkeit (Antriebskraft des Trocknens) und den Eigenschaften der Flächenschicht des Erzeugnisses. Durch das Erhalten des Unterschiedes zwischen aw und relativer Luftfeuchtigkeit, was durch die Regulation der Luftzustromschnelligkeit und Lufttemperatur erreicht wird, wird auch die Antriebskraft des Trocknens erhalten. Durch die stufenartige Migration des Wassers aus den tieferen Fleischteilen auf die Fläche, gleichzeitige Salzdiffusion und andere aufgelösten Pöckelteile im Erzeugnis, durch die Verminderung von aw, neben bakteriostatischer Salzwirkung, entwickeln sich ungünstige Bedingungen für die Entwicklung von Mikroorganismen, was sehr wichtig für die dauerhafte Erhaltbarkeit des Erzeugnisses ist. Zahlreiche chemische Reaktionen im Trocknen- und Reifeprozess von getrockneten Fleischdauererzeugnissen (Enzymehydrolyse, Oxidation und andere), in denen eine große Zahl der verschiedenen chemischen Zusammensetzungen entsteht (dünstbaren und undünstbaren), sind verantwortlich für die Entstehung der gewünschten organoleptischen Eigenschaften des Erzeugnisses, vor allem für Geschmack und Aroma.

Schlüsselwörter: *Trocknen, Reifen, Wasseraktivität, getrocknete Fleisch-Dauererzeugnisse*

Essicamento e maturazione – processi tecnologici fondamentali nella produzione dei prodotti essiccati a lunga durata

Somario

L'essicamento è probabilmente uno dei più vecchi modi di conservare la carne. Il risultato di processo d'essicamento è soprattutto la perdita dell'acqua (disidratazione ed evaporazione) che si rivela come la perdita del peso di prodotto (il calo). Con la riduzione della quantita d'acqua nel prodotto si reduce anche l'attività di microorganismi, e questo infatti prolunga la durata del prodotto. Il cambiamento fondamentale che protegge il prodotto dalla decomposizione è la riduzione dell'attività d'acqua nel prodotto (aw), determinata dall'attività comune di contenuto, sostanze solubili e sostanze con la possibilità di gonfiarsi. Il livello d'essicamento viene ridotto con la crescita della percentuale di sostanze solubili nella carne. Per ottenere il livello desiderato dell'aw del prodotto bisogna combinare altri tipi di conservazione (conservazione sotto sale, affumicatura).

Il valore pH influisce anche all'aw desiderato (influenza sulle proteine capaci di legare l'acqua) in modo che i valori bassi del pH favoriscono i valori alti dell'aw. La velocità con cui si essicano i prodotti di carne dipende prevalentemente dai tre fattori: superficie d'essicamento, differenza tra l'aw e l'umidità relativa dell'aria (la forza movente dell'essicamento), e le caratteristiche dello strato superficiale del prodotto. Mantenendo la differenza tra l'aw e l'umidità relativa dell'aria si mantiene anche la forza movente dell'essicamento. Con la migrazione gradevole dell'acqua da strati più profondi di carne verso la superficie, con la diffusione contemporanea del sale e le altre sostanze di salamoia dentro il prodotto, e con la riduzione dell'aw, con l'effetto batteriostatico del sale, vengono create le condizioni sgradevoli per lo sviluppo di microorganismi, e questo è molto importante per la sostenibile duratura del prodotto stesso. Numerose reazioni chimiche nel processo d'essicamento, affumicatura e maturazione di prodotti di carne essicata di lunga durata (idrolisi enzimatica, ossidazione ecc.) nei quali si forma un grande numero di vari composti chimici (vaporizzanti e non vaporizzanti) sono responsabili per la creazione delle desiderate caratteristiche organolettiche del prodotto, innanzi tutto del sapore e dell'odore.

Parole chiave: *essicamento, maturazione, attività dell'acqua, prodotti essicati di lunga durata*

significant in conditions of good hygienic practices (microbial culture play a crucial role in production of fermented sausages).

Differences in flavor and aroma of certain types of one-piece dry-cured meat products (the most studies has been carried out on different types of ham) are related to the quantity, composition and decomposition of lipids during the processing. Effect of lipases and phospholipases of muscle and adipose tissue on triglycerides and phospholipids, leads to accumulation of free fatty acids whose auto-oxidation (or enzymatic oxidation) results with volatile components of specific aromas and flavors that are associated with the aroma and flavor of certain types of meat products (Timón et al., 2001). Free fatty acids of the final product also depend on the type of cured meat product, whereby raw materials (types and categories of meat, breeding system, feeding, etc.) and process technology (the meat in pieces: salting, drying and ripening methods and duration, etc.) are important.

Figure 2 shows a simplified scheme of enzymatic degradation of lipids in muscle and adipose tissues to free fatty acids (with the presentation of several important intermediate) and of the muscle proteins to peptides and free amino acids, and the impact or resulting products on the flavor and aroma of dry-cured meat products.

Conclusions

Technology of dry-cured meat products is based essentially on the methods of salting, drying and ripening. The most significant changes in the tissues of the product occur during the drying and ripening stages, which are based primarily on the dehydration of product and lowering of a_w (most prominent at the drying stage) and numerous biochemical processes (the most intensive in the ripening stage) that generate different chemical compounds responsible for specific aroma and flavor of the product. Physical and chemical changes in tissues of the products during processing are interrelated, so that one causes the other. Therefore, in the production of dry-cured products is crucial to apply appropriate technological processes that will, given the quality of raw materials, assure the conditions for production of the best quality products.

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