Application of starch based additives in meat industry

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professional review

Summary
Starch and starch derivatives have extensive application in food industry. Application of native starch is limited due to retrogradation, instability in acid conditions, thermal degradation, viscosity changes etc. To improve or achieve desired functional properties, different modification procedures (esterification, cross-linking, oxidation, pregelatinisation etc.) are applied.Starch based additives are extensively applied in meat industry, either single or in combination with other additives (most often hydrocolloids) as water binding agents, emulsifiers, fat substitutes, to improve productivity, stability and texture of meat products.This article gives overview of starch properties, modifications and application in meat industry.
Keywords: *meat products, starch, modified starches*

Introduction

Starch is a carbohydrate, polysaccharide built of glucose units linked with α-1, 4 and α-1, 6 glycosidic bonds in the two polymeric chains, amylose and amylopectin. Production and consumption of starch in the world is steadily increasing due to the positive effects that are archived by addition of starch or its derivatives in the manufacture of various products. The world annual production of starch is around 70 million tons, of which in Europe around 10 million tons (about 50% corn, 30% wheat and 20% potato starch) (Agrosynergie, 2010). The largest producer of starch in the world is the United States with a share higher than 51%, and the most important raw material is corn, that makes 83% of the total world production of starch. In addition to corn, significant raw materials for the production of starch are potato, wheat, tapioca and rice.

Additives based on starch are widely used in the meat industry, where they are used alone or with other additives to bind water, as emulsifiers, fat substitutes, in the development of new products and to improve the efficiency, stability and texture of meat products.

This article gives overview of starch properties, modifications and application in meat industry.

Starch

Starch in nature occurs in the form of granules, which consist of two polysaccharides, amylose and amylopectin, that make 98 - 99% of starch dry matter. Both polysaccharides are built of a-D-glucose units. Amylose is a linear polysaccharide in which glucose molecules are linked with α-1, 4 bonds, while amylopectin is branched molecule in which glucose molecules are, in addition to α-1, 4, linked with α-1, 6 bonds. The shape and size of the granules and the proportion of amylose and amylopectin are typical for the botanical origin of starch (most starches contain 20 - 30% amylose and 70 - 80% amylopectin) (Eliasson, 2006).

Starch is different from all other carbohydrates, due to its unique chemical and physical properties and nutritional value. Starch and its derivatives represent the majority of carbohydrates in the human diet (Eliasson, 2006). Also, the amount of different types of starch (native, modified and hydrolysates), which is used in food production significantly exceeds the other polysaccharides (Babić, 2007). Native and modified starches are used in the food industry as a binding, film forming, foam stabilizing, water binding agents and aromas, emulsifiers, fat substitutes, viscosity enhancing agents, to achieve a certain texture, improve the stability and texture, etc. (Eliasson, 2006). In addition to the functional properties, starches are increasingly used due to lower prices compared to alternative options (Pietrasik, 1999).

Starch granule is physically and chemically heterogeneous, chemically, because it contains amylose and amylopectin, and physically because it contains crystalline and amorphous phase. Undamaged starch granules are insoluble in cold water, but can reversibly absorb a certain amount of water, which causes volume increase of granules (swelling of the starch granules). Starch must be dissolved in most cases of industrial applications. Dissolving of starch is called gelatinisation, and is induced by heating of starch suspensions in water. Dissolving starch leads to disruption of the crystalline structure of granules, melting granules, viscosity increase, loss of optical activity and, in sufficient concentration of starch, gel formation (Singh et al., 2003; Babić, 2007). During cooling of gelatinized system, starch-water system spontaneously reverts to lower-energy state, and dissolved starch molecules are linking by hydrogen bonds in process called retrogradation (Chang et al., 2004). Starch retrogradation could have the following effects: an increase or decrease of viscosity, the emergence of opacity and turbidity, precipitation of crystals of starch, gel formation and release of water from the system - syneresis (Barsby et al., 2001).

Although the native starch has an important application in the food industry, there are some restrictions in the application, which are primarily related to retrogradation, instability in acidic conditions, low stability at high temperatures, the viscosity change during storage, etc. In order to improve or achieve certain specific functional properties of starch different types of modifications are performed.

Modified starches

By treatment of starch with different chemical agents, physical processes, enzymes or through a combination of these procedures modified starches of various functional properties are produced. The term modified starch refers to starch that has altered chemical and / or physical structure in relation to natural starch. The EU Directive 95/2/EC and 98/72/EC amendment modified starches are included on the list of permitted food additives, numbered E1404 - E1451.

The most common chemical processes for modifying starch include esterification, etherification, oxidation and crosslinking. *Starch esters* or *starch ethers* are formed by replacing the hydroxyl group of starch with ester or ether group. The amount of substituted groups in the chain of starch is usually expressed by the degree of substitution (DS), which is defined as the number of moles of substituent per mole of anhydroglucose unit. For the preparation of starch esters designed for use in the food industry acetic anhydride, vinyl acetate, succinic anhydride, oct-1-enil succinic anhydride and sodium tripolyphosphate can be used (Cui, 2005). Gelatinization temperature of acetylated starch is significantly lower, the maximum viscosity is slightly higher, and with cooling the viscosity of acetylated starch increases in relation to native starch. In addition, with acetylation retrogradation is reduced, the capacity of swelling and purity of paste are increased. However, starch acetates are less stable in acidic conditions and during shearing at high temperatures (Babić et al., 2009). Starch ethers are more stable than starch esters, even at high pH values (Šubarić et al., 2012). Starch esters or ethers are widely used in food production, primarily to achieve the proper texture and stability of food products (Saartrat et al., 2005).

Starch contains two types of hydroxyl groups: primary on C-6 atom and the secondary on the second and third carbon atoms. Both types of -OH groups can react with multifunctional reagents, giving *crosslinked starches*. With crosslinking starch granules become stronger, which limits granule swelling and reduces the volume fraction in the aqueous phase, leading to a reduction of maximum paste viscosity (Ačkar et al., 2010). Crosslinked starches are used when a stable, highly viscous paste, resistant to processing at high temperatures or low pH values is needed (Woo and Seibu, 1997).

Oxidized starches have the largest application in the paper and textile industry, but in recent years their use in the food industry is increasing owing to low viscosity, high stability and purity. During the process of starch oxidation partial cleavage of bonds (depolymerization) and oxidation of -OH groups to the carbonyl and carboxyl group occur. Depolymerization of starch causes reduction in swelling capacity and viscosity of starch paste, lowering temperature gelation, increase of solubility and decrease of thermal stability of starch. Because carboxyl and carbonyl groups sterically interfere association of dissolved starch molecules, oxidized starch pastes are clearer and less prone to retrogradation (Ptaszek et al., 2013). In the food industry oxidized starches are used for thickening, formation of the film, linking various food ingredients and as emulsifiers (Lawal et al., 2005).

The most frequent physical processes of modification of starch are: pregelatinization, extrusion, swelling and dextrinization. Modification of starch with physical methods can be applied as a separate process or in combination with chemical modifications.

Pregelatinized starch (PS) is produced by spray or roller drying the previously gelatinized starch or by extrusion. The main characteristic of PS is fast hydration and melting already at room temperature. PS are used as additives in the production of snacks, biscuits, bakery and meat products, sauces and other products which are used in order to achieve certain textures, and for linking different ingredients and water binding (Anastasiades et al., 2002).

Extrusion is the process in which the starch is modified by combined effect of high pressure, heat and shear. Thus starch molecules are split into smaller units, and the crystal structure of starch granules is, depending on the parameters of extrusion, partially

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or completely destroyed. Extruded starches have greater water solubility and initial paste viscosity, lower water-binding capacity and retrogradation in relation to native starch (Eliasson, 2004; Cui, 2005).

Starch annealing is carried out by treating the starch granules in conditions of excess water (> 60% w/w) or moderate humidity (40% w/w) at temperatures above the glass transition (t_g), but below the initial gelatinization temperature (t_i) (Jayakody and Hoover, 2008). Annealing has the following impact on the structure of starch granules: increased stability, crystal growth, partial melting of the crystal, increased temperature gelatinization and thermal stability, but decreased swelling power (Jayakody and Hoover, 2008; Šubarić et al., 2012).

Dextrins are produced with dry thermal treatment of starch, with or without addition of acid or alkali catalyst at temperatures 110-180 °C for 3 - 24 min. This process of modification leads to depolymerization of starch molecules. Compared to native starch, dextrins have lower gelatinization temperature (some are dissolved in cold water), lower viscosity and excellent adhesion properties.

Enzymatic hydrolysis of starch leads to splitting of α-1,4 and/or α-1,6 bonds in molecules of amylose and amylopectin. With starch hydrolysis a great number of different products (modified starches and starch hydrolysates) is produced, which differ primarily in the so-called dextrose equivalent (DE). Dextrose equivalent expresses the percentage of reducing sugars calculated as D-glucose on a dry matter (Šubarić et al., 2005).

The application of starch-based additives in the meat industry

Additives based on starch are widely used in the meat industry, where they are used alone or with other ingredients, usually with hydrocolloids, to bind water, as emulsifiers, fat mimecits, in the development of new products and to improve the efficiency, stability and texture of meat products. Table 1 shows the application of certain groups of modified starches in the meat industry (Tarté, 2009).

Table 1 **Application of common types modified starches in the meat industry (Tarté, 2009).**

Type of modification	The purpose of modification	Functional properties for the meat industry
Substitution	Solubility improvement	Decrease of gelatinization temperature Improving stability in the process of freezing/thawing and product durability
Crosslinking	Stabilization	Resistance to high temperature and low pH
Dextrinization	Hydrolysis	Low viscosity Fat replacements Solubility improvement
Enzymes	Viscosity reduction	Lower viscosity Fat replacements
Octenylsuccinate	Emulsification	Stabilization of emulsions Fat loss reduction

Pregelatinized starches (PS) are dissolved in cold water, so, contrary to other starches, should not be heated to dissolve. They are used as additives to improve product design of the ground meat and for the water binding. Binding of water is particularly important during thermal processing of meat products because meat proteins release water during denaturation (Tarté, 2009). Water binding capacity depends on the amount of added starch and the starch type. PS are added to the brine solution to increase viscosity and to prevent sedimentation. Commonly used PS is potato starch due to the high water binding capacity, and waxy maize starch due to reduced retrogradation and stability in the process of freezing/thawing.

Potato starch has relatively large granules, low fat and protein content, and high water binding capacity. It gives high viscosity pastes and textures satisfying for use in meat products. It begins to gelatinize at a temperature at which proteins release most of the water during the transition (72 - 76 °C) and is used as a supplement to bind water and improve the texture of meat products (Tarté, 2009).

Substituted starches, obtained by treating starch with propylene oxide are applied to improve stability of meat products in freeze/thaw processes (Tarté, 2009). Esterified starches are used to bind water, reduce losses during cooking, improve texture and extend shelf life of meat products. By treating the starch with oct-1-enil succinic anhydride bifunctional groups with hydrophilic and hydrophobic properties are added to starch molecule, and the obtained modified starches have emulsifying properties (Tesch, et al., 2002, Song et al., 2006). These starches are added to meat products to stabilize and keep the fat during cooking. In the production of meat products such as sausages, the addition of substituted starches is especially desirable when using lower quality meat or for products with a high water content. In these products modified starches are usually added in the proportion of 2 - 3% (Tarté, 2009). Also, during the production of specific meat products, which contain a relatively high fat content, such as pate, modified starches with emulsifying properties are added to improve the stability of the product.

Emulsifying starches do not have adequate water holding capacity, therefore in the development of various meat products, according to water content, they are combined with other starches that have a high water-binding capacity.

In the production of canned meat products, crosslinked starches are widely used as a means to achieve the desired texture. In addition, during sterilization they provide a low initial viscosity, which allows rapid heat transfer and a sharp rise in temperature required for rapid sterilization, and later at high temperatures lead to thickening, resulting in a corresponding texture of the product (Whistler et al., 1984).

Starch and modified starches are used as additives to coated fried meat products to improve texture and reduce oil absorption during frying (Primo-Martin, 2012). For this purpose the high-amylose modified starches, that have a property of forming a film and reducing fat absorption (Fiszman and Salvador, 2003), and crosslinked starches, that improve the crispness of the product (Han et al., 2007), are used.

Recently, there is an increasing demand for food products with reduced fat and/or sugar. As a result, demand for meat products with reduced fat content is growing. Fats play a very important role in building structures and achieving appropriate physicochemical and sensory properties of meat products. Therefore, creating meat products with reduced fat content (replacing a specific fat content with raw materials lower caloric value, so called fat replacements) is a very complex activity and a real challenge for the meat industry. When creating meat products with reduced fat content modified starches, hydrocolloids and proteins are combined in order to achieve a satisfactory texture of the product (Kao and Lin, 2006). By using the mentioned supplements, considering that these materials have a high water-binding capacity (especially modified starches and hydrocolloids), the water content in products increases, and thus reduces the price of the products. Dextrins are products based on starch, which are used to replace a specific content of fat in meat products, and to improve the texture of meat products. In addition, dextrins are used as additives in various protective layers and mixtures for coating meat products (e.g. semi-finished products for frying).

As a substitute for fat native rice starch, which after gelatinization gives gel fine creamy texture, can be used. Rice starch has significantly smaller granules than other starches, and because of that, gives pastes and gels with unique rheological properties and texture (Eliasson, 2006).

Maltodextrins with a low degree of hydrolysis, which contain less than 5% glucose, maltose and maltotriose are also used as fat substitutes in the production of various meat products (Ma et al., 2006). Maltodextrins are a group of products based on starch with dextrose equivalent less than 20, and are produced by enzymatic hydrolysis of starch. Except as fat replacements, they are used as additives to achieve certain textures of food products, such as sauces and instant soups. In the production of cooked meat products they are used as a binding agent for different components (Linden and Lorient, 2000).

In the production of surimi products starches are added in order to bind water and improve texture. However, the most important role of starch in the production of surimi products is cost-effectiveness, which is achieved by increasing the proportion of dry matter with addition of starches, as significantly cheaper raw materials (Eliasson, 2004). Combination of native and modified starches in the proportion of 3-8% is commonly used for this purpose (Lee et al., 1992). Commonly used native starches are tapioca and potato starches, and commonly used modified starches are waxy maize, tapioca and potato starch.

Salt affects the taste, reduces losses during frying, bonds water and fat and influences texture of meat products (Fernández-Ginés et al., 2005). Ruusunen et al. (2003) investigated the possibility of replacing a specific content of salt in frankfurters with other additives. Results showed that the reduction of salt in frankfurters (below 1.5%) can be replaced by adding a combination of additives: modified tapioca starch, sodium citrate and wheat shell, to achieve satisfactory quality of the products.

Conclusion

As shown in the paper, starch and starch derivatives are widely used in the meat industry in order to achieve specific properties of products, to reduce price of products, as a replacement for fat, etc. The development of new modified starches and study of combination starches with other non-meat ingredients provides great opportunities to develop new and improve existing products in meat industry.

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Anwendung der Zutaten auf Stärkebasis in der Fleischindustrie

Zusammenfassung

Stärke und Stärkederivate haben eine bedeutende Anwendung in der Nahrungsindustrie. Die Nativstärke hat bestimmte Begrenzungen bei der Verwendung gebunden mit Retrogradation, Unbeständigkeit in saueren Verhältnissen, thermische Degradation, Viskositätänderung u.a. Es werden verschiedene Modifikationsverfahren (Esterifikation, Vernetzung-„umrežavanje", Oxidation, Vorgelatisation u.a.) vorgenommen, um bestimmte spezifische funktionelle Stärkeeigenschaften zu verbessern und zu erreichen. Zutaten auf Stärkebasis haben eine breite Anwendung in der Fleischindustrie, wo sie pur oder mit anderen Zutaten (meistens mit Hydrokolloiden) verwendet werden, dies zwecks Wasserbindung, als Emulgatoren, als Ersatz für Fette, bei Entwicklung von neuen Produkten, sowie für Verbesserung der Nutzung, der Stabilität und der Textur von Fleischerzeugnissen. In dieser Arbeit sind die Stärkeeingenschaften, Stärkemodifikationen und Anwendung der Zutaten auf Stärkebasis in der Fleischindustrie dargestellt.

***Schlüsselwörter**: Fleischerzeugnisse, Stärke, Modifizierte Stärke*

Applicazione dei supplementi a base di amido nell'industria della carne

Sommario

L'amido e i suoi derivati hanno un'applicazione significativa nell'industria alimentare. L'amido nativo ha certe limitazioni nell'applicazione legate alla retrogradazione, instabilità in ambiente acido, degradazione termica, cambio della viscosità e altro. Per migliorare o raggiungere alcune proprietà funzionali e specifiche dell'amido si eseguono vari trattamenti di modificazione (esterificazione, reticolazione, ossidazione, pregelatinizzazione e altri). I supplementi a base di amido hanno un vasto uso nell'industria della carne in cui si usano singoli o con altri supplementi (per lo più con gli idrocolloidi) allo scopo di legare l'acqua, come emulgatori, in sostituzione dei grassi, nello sviluppo dei prodotti nuovi e per migliorare utilizzazione, stabilità e grana dei prodotti di carne.Nel presente lavoro sono rappresentate le caratteristiche dell'amido, la modificazione e l'uso dei supplementi a base di amido nell'industria della carne.

***Parole chiave:** prodotti di carne, amido, amidi modificati*

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KLAONIČKA OBRADA I VETERINARSKI PREGLED

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Građa ovog sveučilišnog udžbenika podijeljena je u osam poglavlja. U uvodnom dijelu autori tumače osnovne pojmove iz područja veterinarskog javnog zdravstva te djelokrug rada veterinara koji obavljaju poslove vezane uz higijenu i tehnologiju proizvodnje hrane. Čitatelj ima priliku naučiti razlikovati i pravilno primjenjivati termine "klaonička obrada" i "klanje." U prvom poglavlju opisani su higijensko tehnološki uvjeti izgradnje i uređenja klaoničkih objekata. Slijedi poglavlje o pregledu životinja prije klaoničke obrade (ante mortem) te ono o prisilnom klanju. Dobrobiti životinja u klaoničkom objektu posvećeno je četvrto poglavlje. Naredno je poglavlje najopsežnije, donosi detaljan opis klaoničke obrade i pregleda mesa goveda, malih preživača, kopitara, svinja,sivljači, peradi, kunića i nojeva. Za svaku su životinjsku vrstu dijagramski prikazane faze rada u klaoničkom objektu. Brojnim fotografijama iz vlastite zbirke autori su nam zorno predočili određene zahvate na životinjama i tehnološke procese snimljene u najmodernijim klaonicama. Detaljne ilustracije i crteži zasjecanja i palpacije limfnim čvorova i drugih organa u svrhu veterinarskog pregleda mesa, iznimno su dragocjeni i edukativni. Razveselit će veterinare praktičare ali i studente koji uče nastavni predmet Higijena i tehnologija hrane. Posebno će biti od koristi kolegama koji pripremaju stručni ispit, ali i podsjetnik ovlaštenim veterinarima koji rade u kontrolnim tijelima. O označavanju trupova nakon post mortem pregleda govori se u šestom poglavlju. Obredna, odnosno ritualna klanja, košer i halal, definirana su i objašnjena u zasebnom poglavlju. Posljednje, osmo poglavlje posvećeno je procjeni uporabljivosti mesa i organa za prehranu ljudi. I to poglavlje obiluje fotografijama patoloških promijenjenih životinjskih organa te grafičkim prikazima razvojnih ciklusa parazita. Najprije je podastrta zakonska osnova propisanih radnji a zatim tehnika post mortem pregleda i prosuđivanje važnih zoonoza. Na kraju knjige nalazi se popis korištene literature i prilozi s raznim obrascima, papirnatim oznakama,izvješćima i evidencijama koje se rutinski rabe u klaoničkim objektima. Ukratko, vrijednost ove knjige je u njenoj posve praktičnoj orijentaciji.

Knjigu možete naručiti putem telefona 01 3779 444 ili kupiti online, u web knjižari Medicinske naklade.

Vlasta HERAK-PERKOVIĆ

VETERINARSKO JAVNO ZDRAVSTVO I SIGURNOST HRANE

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Četrnaest autora, nastavnika Veterinarskog fakulteta Sveučilišta u Zagrebu, napisalo je ovaj moderan sveučilišni priručnik namijenjen studentima. Članovi autorskog tima su (abecednim redoslijedom): prof. dr. sc. Željka Cvrtila Fleck, dr. sc. Ivana Filipović, prof. dr. sc. Lidija Kozačinski, prof. dr. sc. Branimir Mioković, prof. dr. sc. Bela Njari, prof. dr. sc. Željko Pavičić, Marko Poletto, dr. med. vet., prof. dr. sc. Jelena Pompe-Gotal, prof. dr. sc. Andrea Prevendar Crnić, prof. dr. sc. Emil Srebočan, prof. dr. sc. Dagny Stojčević, prof. dr. sc. Alenka Tofant, prof. dr. sc. Marija Vučemilo i dr. sc. Nevijo Zdolec. Priručnik sadržava tri cjeline.

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Vlasta HERAK-PERKOVIĆ