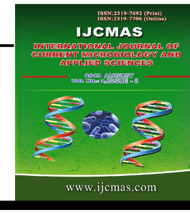

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 2 Number 8 (2013) pp. 169-176**
http://www.ijcmas.com

Research Article

A review on recent advances in meat processing

Allwyn Sundar Raj*, Ragavi Jayaram, Sachin Dev and Sairam Ravikumar

Department of Food Processing and Engineering, Karunya University,
Coimbatore – 641114, TamilNadu, India
**Corresponding author e-mail: asrthegreat@gmail.com*

Keywords

Meat; Processing; Feed borne disease; Nutrition and Protein Profile

A B S T R A C T

Meat has long been known for its nutritive composition which could explain why it is being consumed by many people worldwide. The protein profile of meat consists of amino acids that have been described as excellent due to the presence of all essential ones required by the body. This review explained the general compositional constituents of meat and recent advances of meat processing systems. The nutritional advantages inherent in the consumption meat are also stressed. The current review could prove very useful as good insight in many countries, especially in developing ones, where increased level of nutrition and its factors affecting the quality of meat during processing.

Introduction

Meat is an important element in the diet of most people and its safety depends upon the application of effective control measures at all stages of the production chain, literally from 'farm to fork'. In order to achieve this important objective there has to be co-operation between farmers, feed manufacturers, livestock market operators, livestock hauliers, abattoirs operatives and those working in food processing plants, on the one hand, and on the other, those employed in the meat inspection services and by other regulatory authorities, veterinarians, food technologists and the professionals specialising in occupational medicine, public health and the epidemiology of feed borne disease. In many developing countries, especially Nigeria meat is widely consumed a source of protein; it is either eaten cooked or processed into other forms to avoid associated spoilage (Olaoye *et al*., 2010; Olaoye and Onilude, 2010). Meat is defined as 'the edible part of the skeletal muscle of an animal that was healthy at the time of slaughter (CFDAR, 1990). Chemically meat is composed of four major components including water, protein, lipid, carbohydrate and many other minor components such as vitamins, enzymes, pigments and flavour compounds (Lambert *et al*., 1991). The relative proportions of all these constituents give meat its particular structure, texture, flavour, colour and nutritive value. Meat is a nutritious, protein-rich food which is highly perishable and has a short shelf-life unless preservation methods are used. Shelf life and maintenance of the meat quality are influenced by a number of interrelated factors including holding temperature, which can result in detrimental changes in the quality attributes of meat (Olaoye and Onilude, 2010).

Changing consumer demands and increasing global competition are causing the meat product manufacturing sector to embrace new processing technologies and new ingredient systems, which is remarkable if one considers the historically traditional and long term approach to product and process development in the meat industry. This is likely because the long standing positive consumer perception that meat and meat products are very good sources of minerals, vitamins, and contain "complete" proteins (i.e. proteins that in contrast to many plant-based proteins contain all nine of the essential amino acids) is gradually giving way to a more negative view (Verbeke *et al.*, 2010). Meat and meat product consumption is gradually being seen as causes for increased risks of attracting chronic diseases such as obesity, cancer and stroke. This is particularly the case in the United States, where incidences of obesity, cardiovascular disease, hypertension and cancer are increasing thereby putting an increasing burden on health care systems (CDC National Center for Chronic Disease Prevention, 2005).

Nutritive composition value of meat

Broadly, the composition of meat, after *rigormortis* but before post-mortem degradative changes, can be approximated to 75% water, 19% protein,3.5% soluble, non-protein, substances and 2.5% fat. The proteins in muscle can be broadly divided into those which are soluble in water or dilute salt solutions (the sarcoplasmic proteins), those which are soluble in concentrated salt solutions (themyo fibrillar proteins) and those which are insoluble in the latter, at least at low temperature - the proteins of connective tissue and other formed structures (Lawrieand Ledward, 2006).Proteins of beef consistof essential amino acids such as leucine, isoleucine, lysine, methionine, cystine, phenylalanine, threonine, tryptophan, valine, arginine and histidine; of these the last two are considered essential for infants. Aminoacids are important for maintenance and repair of body tissues in human (Lawrie and Ledward, 2006).

Meat is a very good source of various micronutrients: low-fat pork contains 1.8 mg iron, 2.6mg zinc; and pigs' liver contains 360 mg magnesium,20 mg iron and 60 μg selenium per 100 g. A daily intake of 100 g of meat and liver can supply up to 50% of the recommended daily allowance for iron, zinc, selenium, vitamins B1, B2, B6, B12 and100% of vitamin A (Biesalski and Nohr, 2009). The importance of meat as an essential source of some micronutrients is due to the fact that it is either the ironly source, or they have a higher bioavailability.

Vitamins A and B12 occur exclusively in meat and can hardly be compensated for by plant-derived provitamins (Biesalski, 2005). Vitamin A is also responsible for lung development and maturation and for the development of other tissues, and control of these processes seems to be dependent on the expression of RA receptors. Although liver is the best available source of vitamin A, it has a 'bad reputation due to other potential constituents of this organ, such as heavy metals, hormones or xenobiotics (Biesalski, 2005). In order to obtain the recommended 1 mg retinol per day from vegetables, 500 mg of mixed and β-carotene rich vegetables have to be eaten daily, while 100 g of liver twice a month is sufficient and is neither toxic nor teratogenic (Biesalski, 2005; Nohrand Biesalski, 2007). Vitamin B12 (cobalamin) can be taken up only from animal products; it does not exist in plants. People dieting to lose weight could obviously be at risk of micronutrient deficiencies (Biesalskiand Nohr, 2009). However, the levels of iron, magnesium, zinc, fat-soluble vitamins and essential fatty acids should be controlled during the diet. Ameta-analysis has shown that protein-rich diets that were low in carbohydrates but with a moderate-to high fat content resulted in a better weight loss than diets low in protein and fat, but high in carbohydrates.

Factors affecting product quality

Temperature

In order to control and manipulate particle size and adhesion, it is important to understand the factors affecting them. As well as having a direct effect on eating quality, particle size also affects the appearance of the product, and the available surface area for protein extraction. In grill steak manufacture, the size reduction is a two-stage operation, involving pre-breaking (which achieves a relatively coarse comminution) and flaking (a fine comminution). The temperature of the meat is critical because of its effects on ice content and mechanical properties.

Ice Content

Lean meat at slaughter contains about 75% water. The proportion which freezes depends on the temperature and can be expressed by the equation *I*. 1y*ifp*=*T* where *I* is the fraction of freezable water, *ifp* is the initial freezing point (about y1ºC in lean meat) and *T* is the temperature in ºC The rationale for this behaviour is that solutes naturally present in the meat reduce the freezing point and these become progressively concentrated in the unfrozen liquor, resulting in an ionic strength of about 1Mat y5ºC and 2Mat y15ºC (Offer and Knight, 1988b). Temperatures usually rise during processing, whilst the ice content falls (Sheard *et al.*, 1989, 1990b, 1991a, b). However, the *ifp* is lowered by the addition of salt during mixing – causing ice to melt – and it is not uncommon to see the temperature fall by 0.5 to 1ºC during mixing with salt (Sheard *et al.*, 1990c). Temperatures at the end of mixing and forming are typically around Y2ºC and unlikely to rise much above this unless product has been standing for long periods due to equipment failure. Differences in pre-breaking temperature can lead to relatively large differences in ice content at the end of the processing line, though differences in temperatures are only small and difficult to measure.

Mechanical Properties

In order to understand and predict the effects of high-speed processing on the behaviour of meat during comminution, various authors have investigated the mechanical properties and fracture behaviour of meat under different conditions, to determine tensile strength, work of fracture and other properties using traditional ways employed by materials scientists (Munro, 1983; Dobraszczyk *et al.*, 1987). In common with many biological materials (Ashby, 1983; Atkins, 1987; Atkins and Mai, 1986), the mechanical properties of meat depend on temperature, water content (or ice content), the strain rate (i.e. the rate at which the sample is deformed) and the fibre direction (Dobraszczyk *et al.*, 1987; Munro, 1983; Purslow, 1985). At low temperatures (<y15ºC) meat behaves in a brittle way (breaking suddenly in such a way that the broken ends may be refitted to regain essentially the original dimensions) but exhibits visco elastic behavior (in which samples exhibit extensive deformation before eventual fracture) at higher temperatures (>y10ºC) (Dobraszczyk *et al.*, 1987; Munro, 1983). Munro (1983) showed that meat is highly anisotropic (i.e. the structure and properties of the material depend on fibre direction) above the *ifp* but only slightly so below the *ifp* where the ratio of tensile strengths falls from 5:1 (above the *ifp*) to 2:1. This observation is important because a highly anisotropic material is more likely to produce particles with a preferred fibre direction than a material that is isotropic or slightly anisotropic.

Protein Solubility

As mentioned earlier, the re-assembly of meat pieces once they have been comminuted is an essential requirement in restructuring. Good adhesion ('bind') between meat pieces is widely regarded as a key determinant of quality, usually achieved by adding salt, sometimes in conjunction with phosphate, added dry during mixing. Other means of achieving adhesion are discussed later. In addition to its effect on adhesion, salt also increases water retention, reduces cooking losses and may also increase tenderness slightly. The underlying mechanism involves depolymerisation of myosin and dissociation of actomyosin, at appropriate concentrations, which in turn (i) allows expansion of the myofibrillar lattice (Offer and Knight, 1988a), thus improving water retention characteristics and reducing weight loss on cooking, (ii) effects adhesion on cooking via gelation of the solubilised myosin which binds the constituent meat pieces together and (iii) effects a tenderisation partly due to the increased water retention and partly as a result of the disassembly of the myofibrillar filaments.

Recent advances in meat processing systems

In addition to the above described advances in ingredient systems that may be used to manufacture novel meat products, new processing approaches for the industrial manufacturing of meat products are being developed. Fully automated, continuous production processes with material deliveries by meat suppliers "just in times" can now be found in the meat manufacturing sector (Nollet and Toldra, 2006). Process and machine specifications are adapted from diverse industries such as the automobile, pharmaceutical, chemical and personal care industries. The goal is to not just to decrease variations in product quality but to also increase throughput. In combination with available expertise in mechanical engineering largely driven by advances in automotive tool design, new machines are emerging that are able to fulfill the above outlined requirements. In the context of this new machinery that is emerging, it is important to note that the previously described novel ingredient systems must now be integrated into these new processing schemes.

Coarse Meat Grinders

A large variety of different types of grinders can be found on the market including standard grinders, mixing grinders and frozen meat grinders. In combination with specialized separator blades, hazardous parts such as bones, gristle, sinews and other solid particles can be removed from the meat product (Fischer, 1988a, b). However, while the operating principle may be simple, there are a significant amount of variations with respect to available knife– perforated plate combinations. Pump grinders can increasingly produce finer meat batters. Pump grinders can also handle addition of water instead of ice making operating temperatures above 0°C feasible. This noticeably reduces required cutting forces as materials are viscous rather than a solid. Pump grinder may reduce or eliminate issues such as microbial spoilage and oxidative based on the fact that the raw material is relatively mildly treated and air pockets in the meat batter are reduced by the applied vacuum (Honikel, 2004). Theoretically, pump grinders should therefore able to one day completely replace bowl choppers in the production of fine disperse batter (Haack, 2001a, b, c). To date, pump grinders are mostly used for the continuous manufacturing of raw fermented sausages although development of fine dispersing systems is underway (Buchele, 2009).

Fine Meat Homogenizers

From the standpoint of traditional processing of emulsion-type sausages of the frankfurter type, bowl choppers are the preferred production equipment. However, as production quantities grow due to consolidation of meat product manufacturers, bowl choppers had to be further and further increased in size. Today, bowl choppers with volumes of 1200 L are available for industrial production of fine sausages (Seydelmann, 2002, 2009). Thus, bowl choppers are beginning to be replaced by continuously working fine homogenizers that have design principles similar to those of colloid mills and high shear dispersers used in the broader food industry to manufacture products such as for example mayonnaise. In these systems, residence times are short and “dead volumes”, that is volumes where no processing occurs, are low (Inotec, 2009). Residence times can be easily regulated by adjusting volume flow rates.

Slicers

In many supermarkets, the amount of sliced and packaged convenience meat products in the refrigerated section increases while demand for over-the-counter meat products decreases. Consumers prefer the longer shelf life of meat products that is achieved when products are sliced under hygienic conditions followed by vacuum or modified atmosphere packaging (Fankhanel, 2008). Continuous slicer lines are increasingly installed by meat product manufacturers (Holac, 2009). Slicers represent the last in the line of meat production processing steps and are often used in combination with portioning units and/or stacking/shingling devices (Rust, 2004). Today, software is available that allows meat manufacturers to custom design decorative patterns and combine single, shingles and stacks. This is important since the display of sliced products has become a key selling point (Heinrich, 2008).

This review article reviewed advances in the development of manufacturing systems for meat processing. It highlighted that developments are proceeding at an increasing pace. Driven by the demand for new products with new formulations, the meat industry is forced to install flexible production lines that can generate large quantities of high quality meat products. Many nutritional advantages are inherent in the consumption of meat. However, in meat, there are some associated undesirable changes and microbial agents which could constitute major disadvantages when necessary precautions are not observed during processing. Ultimately, machine designers, process engineers and meat scientists will need to work more closely together to close this gap in the knowledge base. Meat scientists have an important role to play in this process. They are uniquely positioned to bridge the gaps between the different disciplines and thereby help the meat manufacturing sector to prosper.

References

Atkins, A.G., and Mai, Y.W. 1986., 'Deformation transitions', J Materials Sci. 21: 1093–1110.

Atkins, A.G., 1987. 'The basic principles of mechanical failure in biological systems', in Blanshard, J .M. V. and Lillford, P. Food Structure and Behaviour, London, Academic Press. pp.149–176.

Ashby, M. F., 1983. 'The mechanical properties of cellular solids', Metallurgical Trans A, 14A.pp. 1755–1768.

Biesalski, H.K., 2005. Meat as a component of a healthy diet – are there any risks or benefits if meat is avoided in the diet?. Meat Sci. 70: 509–524.

Biesalski, H.K., and Nohr, D. 2009. The nutritional quality of meat. In: J.P. Kerry and D. Ledward (eds). Improving the sensory and nutritional quality of fresh meat, 1st edn. Cambridge: Woodhead Publishing Ltd, England.

Boelsma, E., H.F. Hendriks and Roza, L. 2001. Nutritional skin care: Health effects of micronutrients and fatty acids. American. J. Cli. Nutrit.73: 853–864.

Buchele, A., 2009. Produkt qualitat /Technologisches Potenzialfreisetzen /Fullwolftechnologiezursicheren Herstellungattraktiver Rohwurst-produkte. Fleischwirtschaft, 89(8): 44−45.

CDC National Center for Chronic Disease Prevention., 2005. Number of Americans with Diabetes Continues to Increase. In O. o. Communication (Ed.), (Vol. CDC).

CFDAR., Canadian Food and Drugs Act and Regulations. 1990. With amendments to May 3, 1990. Section 14, Paragraph B.14.002.[S], Ottawa: The Queen's Printer. pp. 64.

Dobraszczyk, B. J., A.G. Atkins, G. Jeronimidis and Purlsow, P. P. 1987. 'Fracture toughness of frozen meat'. Meat Sci. 21: 25–49.

Fischer, A., 1988a.Maschinenand Anlagen. In O. Prandl,A. Fischer, T. Schmidhofer,&H. -J. Sinell (Eds.), Fleisch - Technologie und Hygiene der Gewinnung und Verarbeitung, Ulmer. (pp. 373−487.

Fischer, A., 1988b. ProduktbezogeneTechnologie - Herstellung von Fleischerzeugnissen. In O. Prandl, A. Fischer, T. Schmidhofer, & H. -J. Sinell (Eds.), Fleisch - Technologie und Hygiene der Gewinnung und Verarbeitung. Ulmer. pp. 488−593.

Fankhanel, J., 2008. Precise positioning of slices and packs/growth in the self service market influences slicing technology and equipment. Fleischwirtschaft Inter. 4: 36−37.

Haack, E., 2001a. IFFA 2001/Trends in der Zerkleinerungstechnik/1.Wolfe entwickelnsichimmermehrzuAllround maschinen in der

Fleischverarbeitung.Fleischwirtschaft, 81(07): 34−43.

Haack, E., 2001b. IFFA 2001/Trends in der Zerkleinerungstechnik/2.WachsendesAngebotbeiFüllwolftechnikoderFüllmaschinenmitintegriertenWolfen. Fleischwirtschaft, 81(08): 26−31.

Haack, E., 2001c. IFFA 2001/Trends in der Zerkleinerungstechnik/3.Elektronische Prozess-Steuerung und hygienisches Design beiKutternweiterverbessert.Fleischwirtschaft, 81(09): 54−59.

Heinrich, H. J., 2008. Increasing productivity slice by slice/precise coordination of cutting, transport and weighing machinery for exact-weight slicing and controlled portioning. Fleischwirtschaft Inte. 4: 34−35.

Honikel, K. O., 2004. Minced meats.In C. Devine, M. Dikeman, & W. K. Jensen (Eds.), Encyclopedia of meat sciences, Oxford: Elsevier. pp. 854−856.

Holac., 2009.Holac/continuous high-volume slicing.Fleischwirtschaft International, 4.

Inotec., 2009. Inotec/HomogenesSchnittbilddurchkontinuierlicheProduktion.Fleischwirtschaft, 89(12): 60.

Lambert, A.D., J.P. Smith and Dodds, K.L. 1991.Shelf life extension and microbiological safety of fresh meat - A review. Food Microbiol. 267-297.

Lawrie, R.A., and Ledward, D.A. 2006. Lawrie's meat science. 7th ed., Woodhead Publishing Ltd, Cambridge: England and CRC Press Boca Raton, New York, Washington DC. pp. 75-155.

Munro, P .A. 1983. 'The tensile properties of frozen and thawed lean beef'. Mea.t Sci, 9: 43–61.

Offer, G., and Knight, P. 1988a. 'The structural basis of water holding in meat Part 1 General principles and water uptake in meat processing', in Lawrie R A, Developments in Meat Science 4, London, Elsevier Applied Science.pp. 63–171.

Offer, G., and Knight, P.1988b. 'The structural basis of water holding in meat Part 2 Drip losses', in Lawrie R A, Developments in Meat Science 4, London, Elsevier Applied Science, London.pp.173–244.

Olaoye, O.A., and Onilude, A.A. 2010. Investigation on the potential use of biological agents in the extension of fresh beef in Nigeria. World J. Microbiol. Biotechnol. 26: 1445–1454.

Olaoye, O.A., A.A. Onilude and Idowu, O.A. 2010. Microbiological profile of goat meat inoculated with lactic acid bacteria cultures and stored at 30°C for 7 days. Food and Bioprocess Technology DOI: 10.1007/ s11947-010-0343-3. In press.

Purslow, P. P. 1985. 'The physical basis of meat texture: observations on the fracture behaviour of cooked bovine *M.semitendinosus'*, Meat Sci. 12: 39–60.

Rust, R. E., 2004. Processing equipment|mixing and cutting equipment. In C. Devine, M. Dikeman, and Jensen, W.K. Encyclopedia of meat sciences, Oxford: Elsevier. pp. 1057−1061.

Sawyer, R., 1975. The Composition of Meat; Analytical Aspects. In Cole, D.J.A. and Lawrie, R.A. (Eds), Meat, London: Butterworths, UK. pp. 287-301.

Seydelmann., 2002.Technologie/High-Tech fur optimales Brat. Fleischwirtschaft, 82(3): 41.

Seydelmann., 2009. Seydelmann/Zerkleinerung in mehrerenvertikalangeordnetenEbenen.

Fleischwirtschaft, 89(12): 59.

Sheard, P. R., Jolley, P. D. Hall, L. D. and Newman, P .B. 1989. 'Technical note: the effect of temperature and raw material on the size distribution of meat particles pre-broken by grinding', Int. J. Food. Sci. Tech. 24: 421–427.

Sheard, P. R., P.D. Jolley, R.K. Mounsdon and Hall, L. D. (1990b. 'Factors influencing the particle size distribution of flaked meat I Effect of temperature, aperture size and pre-breaking before flaking', Int. J. Food Sci. Tech. 25: 483–505.

Sheard, P. R., P.D. Jolley, A.M.A. Katib, J.M. Robinson and Morley, M. J. (1990c. 'Influence of sodium chloride and sodium tripolyphosphate on the quality of UK-style grillsteaks: relationship to freezing point depression', Int .J.Food. Sci. Tech. 25: 643–656.

Sheard, P.R., A. Foster-Smith and Jolley, P. D. 1991a. 'Factors influencing the particle size distribution of flaked meat II Effect of aperture size, number of cutting stations, rotational speed and impeller design'.Int .J.Food. Sci Tech. 26: 65–81.

Sheard, P. R., P.D. Jolley and Rush, P. A. J. 1991b. 'Effect of temperature on the particle size distribution of flake-cut meat'. Int .J. Food.Sci. Tech. 26: 199–205.

Verbeke, W., F.J.A. Perez-Cueto, M.D. de Barcellos, A. Krystallis and Grunert, K.G. 2010. European citizen and consumer attitudes and preferences regarding beef and pork. Meat Sci. 84: 284−292.