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Research Article

Bromatology: What We Do and What We are About

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Abstract: Bromatology plays an important role in the entire food complex and associated systems. This field has become increasingly sophisticated and the associated responsibilities have diversified. The present review aimed to provide a summary for bromatology into four main subfields: food product development, food physiology, food engineering and food security. Bromatology involves food product development of conventional products, animal foods, nutraceuticals, specialized diets, food additives and food packaging material. The physiological impact of foods is critical and can relate to aspects of nutrition, food toxicology, microbiology and psychology. Food engineering incorporates diverse areas including industrial scale food production, effects of food processing, management of food waste, genetic modification and agriculture. Food security refers to topics surrounding food safety, food forensics and food defense. This summary stimulates bromatology professionals to ponder the bigger picture of our field and encourages interactions with bromatology professionals working in different areas of bromatology. Only through interactions and co-operations are we able to efficiently and continuously tackle the intricacies of the food complex and associated systems, to feed the world today and the days to come. It also demonstrates the values and identity of bromatology to others that are not working within the field.

Keywords: Food engineering, food forensics, food physiology, food product development, food science, food technology

INTRODUCTION

Bromatology (interchangeable term with food science and food technology) is a field that integrates a wide array of disciplines associated to the science of food, food-derived products and food related aspects. With the progressing sophistication of this field, the scopes of bromatology have diversified. The aim of this review is to provide a summary on the key aspects in which bromatology deals with, using evidence from recent research activities.

The field of bromatology has been reviewed in detailed before (Floros *et al*., 2010) and the present work reinforces this with additions of relevant responsibilities that the previous review did not address. This summary does not intend to provide a comprehensive review of any of the subfields mentioned but endeavors to string together an overall picture of the field.

The responsibilities listed here are not exhaustive but a work in progress to encourage further consultation and discussion among bromatology professionals. It may also include topics that are relevant to other fields, but it is important to note that in the world today, no field is exclusively confined and it is in my opinion imperative to engage inter-disciplinary approaches to facilitate advancements.

Through this review, it aims to provide a wider view on the scope of bromatology in order to help those unfamiliar with the field to see the values and identify of bromatology and stimulate interactions among bromatology professions within different bromatology subfields.

The listed topics can be divided into four main subfields including food product development, physiological responses relating to food (food physiology), food engineering and food security. All of these sub-fields use fundamental bromatology knowledge in food chemistry, food physics and food biology.

Food chemistry refers to the chemical properties of the food, ranging from the composition and the chemical interactions of dietary components with each other or other relevant factors, such as the environment and biological systems (DeMan, 1999). Food physics concerns the physical properties of food from its general characteristics (e.g., water activity, mass, geometric properties) to its rheological properties, interfacial phenomena, permeability, radioactivity and thermal, electrical, magnetic, optical and acoustical properties (Figura and Teixeira, 2007). Food biology then deals with the general biological properties of food. For example, the ripening and senescence of fruits, microbiology interactions with foods in aspect of probiotics and fermentation, as well as the physiology of muscle foods (Giovannoni, 2001; Harper, 1999).

MATERIALS AND METHODS

The objective of this review epitomizes the field of bromatology and encapsulated its expanding horizons to sustain the global food complex and associated systems. This was approached lightly in order to attempt to cover the entire umbrella of bromatology topics including food product development, food physiology, food engineering and food security. This was supported with evidence from cutting edge research conducted using concepts in food chemistry, food physics and food biology. Through these insights, future opportunities in bromatology can be encouraged from those within the field as well as those that are not.

This review drew upon the essence provided by Floros *et al*. (2010) to lay an important backbone for this review to expand upon. Insights were obtained from research activities presented in bromatology-related scientific journals such as Advanced Journal of Food Science and Technology, Annual Review of Food Science and Technology, Trends in Food Science and Technology etc. These demonstrate the broadening of the field to areas previously under-appreciated. Activities and conference presentations from key bromatology-related associations also provided valuable insights including The Pakistan Society of Food Scientists and Technologists, Institute of Food Technologists, European Federation of Food Science and Technology etc.

RESULTS AND DISCUSSION

Food product development: A key aspect to the bromatology career is food product development. This involves either creating novel products or improvement and modification to existing products (Costa and Jongen, 2006). Aside from the conventional food products, other areas of food product development include development of specialized diets, nutraceuticals, animal feeds, food additives and food packaging material.

From a consumer's point of view, the ideal food product needs to be palatable, convenient, safe and healthy and therefore provides an exciting challenge for the food industry to produce new or improved concepts that possesses these characteristics (Winger and Wall, 2006). An example of a recent novel food product is Cheddar cheese that is microencapsulated with *Bifidobacterium longum* using an alginate based system (Amine *et al*., 2014).

It is well-established that particular groups have specialized needs for certain diets such as for the elderly, infants and those with food allergies or intolerances. Astronauts also have special dietary requirements to accord with their unique partial gravity environment. They require a food system that is sustainable in long duration missions in aspects of palatability, convenience, health and safety (Cooper *et al*., 2011). Simultaneously, there are limitations on the amount of waste and volume the food can produce (Cooper *et al*., 2011).

Aside from foods for humans, increasing attention is given to pet foods due to the increase in pet adoption in developed countries (Van Rooijen *et al*., 2014). Furthermore, the feeds for agricultural animals are also progressively well-regarded due to the appreciation for the impact of animal feed on their final product quality (Rasmussen *et al*., 2014).

There is an expanding public awareness of the relationship between food and health which results in the growing demand for nutraceuticals (Kalra, 2003). Nutraceuticals are health-promoting food-related products that may take the form of tablet supplements or whole-foods (Zeisel, 1999). From the CDC's National Centre for Health Statistics, it was found that more than half of US adults take dietary supplements (Bailey *et al*., 2013). These high market demands have stimulated much bromatology research on nutraceuticals and how they can complement modern medicine (Braithwaite *et al*., 2014).

The use of food additives remains controversial for their safety and health, thus the development of novel or improved food additives that circumvents these concerns are critical. An example is the recent developmental work that produced a superior functioning gum Arabic alternative using synthetical chemistry (Wang *et al*., 2014).

The food packing material comes in proximity with the food and requires special considerations as undesirable material from the food packaging may migrate into the food matrix (Rudel *et al*., 2011). Additionally, with the importance to reduce wastage associated with the food system, various edible packaging research has been done to tackle this problem. For example, recent research utilized a combination of lysozyme and low methoxyl pectin complexes to develop an antimicrobial edible food packaging (Bayarri *et al*., 2014).

Food physiology: Many illnesses are profoundly influenced by dietary habits including obesity, diabetes, cardiovascular diseases and cancer (Nishida *et al*., 2004). Therefore, the physiological impact of food, food derived products and food related aspects are important considerations for bromatology professionals in any area they are working in.

These physiological impacts may concern the nutritional aspects, food toxicology, microbiological impact associated with foods and psychological effects. There is also emerging understanding of the contribution of genetics to these physiological responses to food as evident from the development of nutrigenomics and nutrigenetics (Camp and Rujillo, 2014) as well as the looming concept of food toxicogenomics (Stierum *et al*., 2005).

While food is well-established to exert nutritional effects, the advancement in medical technologies allows other food delivery methods not limited to oral consumption. In some compromised individuals, their digestive systems are unsuitable for oral delivery of food and require nutrition from the enteral or parenteral route to sustain their life (Vincent, 1993).

Food toxicology refers to the adverse effects associated with foods including carcinogenesis, animal food toxins (e.g., prions), marine toxins (e.g., paralytic shellfish poisoning, tetrodotoxin from puffer fish), plant food toxins (e.g., lectins, goitrogens), fungal toxins (e.g., aflatoxins, fumonosins), artificial contaminants (e.g., chlorinated hydrocarbons, heavy metals), pesticide residues, food additives and food processing-induced toxins (Shibamoto and Bjeldanes, 2009). Benign dietary components may also exhibit toxicological effects at sufficiently high doses and therefore all food-related components have been assigned a median Lethal Dose (LD_{50}) (Akhila *et al*., 2007).

Microorganisms can influence our physiological response through pathogenic effects from bacteria, viruses and parasites or beneficial effects in the case of probiotics (Fratamico *et al*., 2005). There is an increasing amount of interest in recent years on the interactions between diet and our microbiota (Chewapreecha, 2014). Recent research includes the discovery that the gut microbiota metabolism of dietary fibre influences allergic airway disease and hematopoiesis (Trompette *et al*., 2014). Another study showed that the gut microbiota may reduce intestinal barrier crossing by the common foodborne pathogen, *Listeria* spp. Through a micro RNA mechanism (Archambaud *et al*., 2013).

Food psychology alludes to the psychological impact of food or in contra how psychological events can influence the perception or other physiological responses to food. This area incorporates the well-known sphere of sensory science to assess the palatability of food and evaluates results using scientific principles (Prescott, 1999). It concerns in part the neurological aspects of olfactory, gustatory and chemesthesis receptor interactions to facilitate overall perception of food (Prescott, 1999). Furthermore, food psychology also looks into the appetite-regulating pathways that are strictly controlled by the hypothalamus (Wilding, 2002). This area answers many interesting question in bromatology such as how chocolate can induce a positive mood through the stimulation of serotonin neurotransmitter in the brain (Parker *et al*., 2006) and how the type of music played or cutlery used during food and beverage consumption can influence the overall perception of food (Harrar and Spence, 2013; Spence *et al*., 2013).

Food engineering: The application of engineering concepts such as mathematical modelling to food and related materials provides valuable perspectives in the food industry. Food engineering covers many aspects ranging from general mass production of food (manufacture, packaging, distribution), the influence of different food processing on the food matrix, the management of the waste streams derived from food production, genetic manipulation or selection for improved foods as well as other relevant agricultural aspects.

The mass production of food is important to deliver scientific systematic process optimized prototypes from the laboratory scale to the industrial scale that must be replicated in all parameters of the product to deliver the ideal product to each consumer. Recent attempts have been made to industrialize supercritical carbon dioxide extraction of algal lipids (Taher *et al*., 2014).

There has been extensive development of novel food processing methods including high pressure processing, pulsed electric field, osmotic dehydration, athermal membrane processing, high intensity pulsed light, radio frequency, ultrasound and irradiation (Sun, 2005). Each of these methods would influence different food matrix differently (Sun, 2005). The understanding of these effects are important both at the time of production as well as longer term storages, to enable optimization the quality of the final product.

Waste and by-products can arise from multiple steps within the food supply chain (Parfitt *et al*., 2010). This can initiate from the harvesting stage, during the manufacture and then at the final consumption by consumers. Undesirable foods, expired foods and food packaging are discarded in gross amounts (Parfitt *et al*., 2010). It is therefore vital to reduce this waste to facilitate a more efficient and sustainable food complex and associated system. Recent research demonstrates the progress within this area. A study was conducted that promotes the value of by-products from mango processing to be used as bioactive nutraceuticals (Dorta *et al*., 2014).

Genetic manipulation of food has been done for a long time using trait selection to obtain the best cultivar or animal (Uzogara, 2000). Comparatively more recent, technological advancements have allowed the direct DNA insertions to generate the trait of interest (Uzogara, 2000). This technology provides an array of benefits to the food complex and associated systems. It allows increasing the availability, palatability, shelf life, nutritional quality, yield, biological defense and environment protection of the food (Uzogara, 2000). A recent example of genetically-modified food is the Atlantic salmon that contains a growth hormone-regulating gene from Pacific Chinook salmon and a promoter from an ocean pout to accelerate their growth and reduce time to reach market size (Amin *et al*., 2014).

A lot of the foods that we have today continue to rely on agriculture including vegetables, fungi, animal products and aquaculture. Therefore, advancements in agricultural practices allow optimization of food productions and their end quality. Some examples includes that the irrigation quality may influence the pathogenic load on crops (Oliveira *et al*., 2012) and the use of bovine somatotropin growth hormones can impact the composition of the beef muscle (Qudus *et al*., 2013).

Food security: Food security refers to the access of sufficient and quality food to fulfil population demands and requirements (Pinstrup-Andersen, 2009). Within food security, food safety is a well acknowledged area that is exceedingly important for bromatology (Kaferstein and Abdussalam, 1999). However, comparatively less characterized is the emerging concept of food forensics (Primrose *et al*., 2010).

It is estimated that 10% of the commercially available food products are fraudulent and not what they claim to be (Primrose *et al*., 2010). This could be an unintentional effect due to insufficient knowledge of the company or a lack of stringent control procedure implementations. Alternatively, this food fraudulence may be intentional, frequently to increase economic gains.

Food forensic strategies are therefore required to determine the validity of product claims such as in the nutritional content and allergen-free status. The recent trends in consumer demands also increases the importance of this validation including appeals for genetic modified free or organic foods and other religion-based requirements such as vegetarian and halal. Recently, a novel DNA mini-barcode assay was developed to authenticate the presence of *Gingko biloba* in claimed nutraceuticals (Little, 2014). Another example is the development of a Raman spectroscopy method to discriminate horse meat in food products in response to the horsemeat scandal in 2013 (Boyaci *et al*., 2014).

Food forensics is also responsible for determining the characteristics and the origins of various food safety compromising agents including those from food poisoning, food adulteration and industrial contaminants (Everstine *et al*., 2013). In China, a food poisoning outbreak of *Bacillus cereus* was characterized from the consumption of their traditional fermented black beans (Zhou *et al*., 2014). Toxic metal can be a problem in many food systems and this was investigated in both canned and fresh foods in Arabia (Al-Thagafi *et al*., 2014).

Food security also deals with import and export of organisms and items into the country that may affect the food complex and associated systems of their nation. This concerns regulations in passing customs with products that contain foodborne pathogens (Schoder *et al*., 2014) or more acknowledged problems such as bovine spongiform encephalopathy (McCluskey *et al*., 2005) and the New Zealand painted apple moth (Suckling *et al*., 2005).

Furthermore, food security is about preventing intentional malignant attacks such as the Rajneeshee bioterror attack to the food complex and associated systems. This food terrorism occurred in 1984 in Oregon that led to the food poisoning of 751 individuals through salmonella contamination in salad bars (Torok *et al*., 1997). It also harbors the thinking surrounding management for upcoming or occurred natural disasters. An example of this type of food security was addressed following the 1998 Bangladesh floods that caused major damage to their rice crop as well as other food security issues (Ninno *et al*., 2003).

CONCLUSION

Food and beverages are essential parts of our lives. However, this entire food complex and associated systems are extremely intricate. Each condition the food is subjected under can alter the native composition or structure at the molecular, macromolecular and supramolecular level that in turn affects the end physiological impacts upon consumption.

Therefore, it requires synergy from different aspects of bromatology including food product development, food physiology, food engineering and food security to interact and work together to continue feeding the growing population.

The mission of bromatology is to maintain and facilitate physical, social and economic access at all times to a satisfactory range of food and food derived products that are healthy, safe, sensory positive and convenient to fulfill individual dietary preferences and requirements for an active healthy lifestyle.

The field of bromatology incorporates diverse sub-disciplines. Through acknowledging many of the different aspects that are involved, it provides future opportunities for connections between bromatology professionals working in different areas. For others, this summary supplies a general view of the responsibilities in bromatology to demonstrate our values and identity.

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