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Modern gastronomic technologies in optimization of pro-health food potential

Abstract

All human senses participate in the sensory evaluation of food, which means that such features as taste, flavour, appearance, or texture determine the acceptance and choice of a dish. Seeking to satisfy consumer requirements and offer a dish or food with the desired organoleptic features, the food industry initially used a wide range of food additives compensating for the loss of colour, taste or flavour of the dish. At present, with an increase in consumers' awareness and nutrition knowledge, departure is observed from the use of food additives to the benefit of using modern technologies in the food industry. The progress in food science, concerning especially, the phenomena taking place during the storage or processing of food, gives direction to the application of modern technical solutions or materials, and also provides guidelines within the area of gastronomic technology concerning the shaping of not only organoleptic features of the dish, but also activities aiming at the preservation of pro-health potential of food. This issue becomes even more important in the context of increasing epidemics of chronic non-communicable diseases (NCD) in contemporary western societies, in the etiopathogenesis of which, health behaviours play a crucial role. The subject of the report will be analysis of the current state of knowledge in the area of food and nutrition sciences, concerning the possibility of using modern gastronomic technologies in order to preserve or enhance the pro-health potential of food, possible to use within the primary and secondary prevention of NCD.

Keywords: gastronomic technology, pro-health food, chronic non-communicable diseases.

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INTRODUCTION

Gastronomic technology remains under the effect of the realities of a given epoch, social and economic, as well as epidemiological. This implies the necessity for consideration in this area of not only the requirements imposed by contemporary societies, anticipating new, attractive physicochemical features of food, but also the application in gastronomy of medical requirements concerning nutrition in preventing civilisation diseases [1]. The leading challenges in this respect result from the world epidemics of chronic non-communicable diseases (NCD), due to which, in 2015, on a global scale, 39.5 million people died (which constitutes 70% from among the 56 million deaths worldwide). At the same time, it should be emphasized that in 2015 in the countries with a low or mediocre level of income, approximately 48% of deaths due to NCD were premature deaths in individuals under the age of 70. In the etiopathogenesis of the leading causes of mortality worldwide indicated by the WHO, i.e. cardiovascular diseases, cerebral stroke, cancer and diabetes, human life style, including the style of nutrition, of the utmost importance. This implies that the potential of prevention of NCD is, to a great degree, unused, and 80% of premature deaths due to these causes may be possibly avoided in the situation of an effective modification of nutritional behaviours, including the risk factors for NCD [2]. This imposes specified requirements on contemporary gastronomic technology, which should function as an area of practical activity; however, based on the progress of scientific knowledge concerning the conditioning of human health, placing itself on the border of food and nutrition sciences and medical sciences. Such an attitude is represented by Virginia Navarro et al., who, while using the concept of '*science-based cooking*', attracted attention to the fact that it is necessary to apply in this area not only the knowledge of the technology of nutrition, but also knowledge concerning human nutrition and nutritional conditioning of health [1]. C. Vega and J. Ubbink [3] point out that a basis of '*science-based cooking*', understood as '*the application of the principles and tools from science for the development of the new dishes*' is molecular gastronomy, offering scientific explanation of the processes related with the preparation and consumption of dishes – '*scientific understanding of the cooking and eating processes*'. The problems concerning these areas are the subject of the presented report.

It is justifiable to tackle issues within the scope of '*science-based cooking*', because full value and optimum nutrition, which would satisfy the demand for energy and indispensable nutrients, is needed for the normal functioning and optimal development of the human body. The recommended amounts of the consumed nutrients change and depend on the stages of the human life cycle, while on the other hand, they are subject to modifications resulting from the development of medical

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knowledge of the NCD etiopathogenesis. It is noteworthy that as early as in 1893 an American dietician and nurse, Ella Kellogg, in her publication '*Science in the kitchen*' argued that the art of cookery cannot be delayed with respect to scientific progress, and should not be based on exclusively practical principles. The origin of scientific approach to cookery techniques already existed in the 18th century, when Jean-Anthelme Brillat-Savarin in his book on cookery issues explained chemical phenomena accompanying cooking. The physicist Benjamin Thompson-Rumford, a specialist in thermodynamics, author of a 400-page essay entitled: '*On the construction of kitchen fire-places and kitchen utensils, together with remarks and observations relating to various processes of cookery and proposals for improving that most useful art*' (1794), contributed largely to the development of kitchenware and appliances for thermal processing. He was the constructor of utensils which were revolutionary at that time: a pot for steaming, pressure cooker, or an oven for baking. Despite many novel solutions, food technology was still considered an inferior branch of science, and treated more as an art than a science. The onset of a scientific approach to cookery techniques in modern times was observed in the 1960s, when the technology of the cold storage of food was developed – the so-called Nack system [4].

Food industry enterprises, frequently specializing in only one group of food products and having at their disposal modern machinery pools, are able to offer the consumer products at various stages of preparation for consumption. In turn, catering facilities possessing limited equipment must process raw materials belonging to all groups of food products and, at the same time, satisfy the requirements of consumers who apart from sensory quality, also expect from dishes a high nutritional value. Modern technologies, which enable the production of dishes in catering facilities, may be used with different production systems [5].

The traditional system is based on 3 stages: production, storage, and dispatch, with the storage time reaching up to 60 minutes and the temperature of 66°C

- a'la carte ordering system – consisting of production and dispatch;
- 'fast-food' system – 3-stage but with a maximum storage time of products up to 15 minutes at the temperature of 66°C;
- 'cook-chill' system – 3-stage with storage temperature from -1 to +3°C and time up to 5 minutes;
- 'cook-freeze' system – 3-stage with storage temperature of -20°C and time from 1 to 3 months.

From the nutritional point of view, the a'la carte system seems to be most beneficial; however, considering the difficulties with implementation, in dietary nutrition this model is frequently displaced by the traditional system, i.e. the so-called cook-chill model. Irrespective of the adopted system of food production, each raw food material should be subjected to processing to enable its consumption. The correctness of the processes performed largely decides about its effect on the consumer's health.

Preliminary processing

The method of storage of raw materials and their preliminary or thermal processing exert an effect on the nutritional value of food. Irregularities in this respect may lead to the obtaining of products with a low nutritional value, or even dangerous for the consumer's health. Considering the fact that for catering facilities the sensory value of dishes is the most important, it is worth noting that in the case of meat, it depends to a great extent on the mode of animal feeding and correct performance of post-slaughter processes. The meat of slaughtered animals obtained directly after slaughter is not a full value raw material, because it is hard and rubbery, with low juiciness, stodgy, and the nutrients are absorbed to a limited degree [6]. Such meat requires a maturation process at low temperature, during which physical and chemical changes take place with the participation of endogenous muscle enzymes. For a gastronome, the most perceptible qualitative change in raw material during the maturation of meat is an increase in its crumbliness. Such factors as the physiological status (age), genetic (gender, race, species), or the increasingly more often discussed mode of animal nutrition, play an important role [7]. According to Razminowicz et al. [8], the meat of animals bred in intensive and extensive conditions does not show any significant differences in crumbliness, and correctly performed maturation process eliminated these differences. The satisfactory crumbliness of beef may be obtained after 10-14 days of conditioning of meat at cooling temperature, while veal and sheep meat – after 4-7 days, pork – after 3-5 days, and poultry – after 0.5-1 day [6,9].

The process of maturation of meat is generally performed in meat processing plants engaged in animal slaughter and cutting and boning of meat; nevertheless, refrigeration equipment may be observed in gastronomic facilities which serve grilled dishes of beef.

Food packaging and storage

During storage of food (raw materials and products), its quality deteriorates under the effect of oxygen, light, or microorganisms, resulting in a decrease in durability. The presence of oxygen causes a number of unfavourable changes, such as rancidification of fats (auto-oxidation), oxidation of vitamin C, vitamin E, beta-carotene and some amino acids. These changes are manifested as the deterioration of colour, taste and flavour of the dish. The so-called 'smart packaging' enables control of the state of safety of the product during the period of storage. It utilizes micro-sensors controlling chemical storage changes in a product or colourful indicators signalling the lack of adequate sealing of a package, increase in the number of microorganisms, as well as storage time and temperature [10].

By limiting the access of oxygen, it is possible to prolong the shelf-life through, among others, inhibition of the development of aerobic bacteria, yeast and moulds [11]. In the catering industry, the process of vacuum packaging is used to prolong the durability of raw materials and products, increasing the shelf-life of the product by several to several dozen days. Vacuum packaging of food in gastronomic facilities is of special importance, because products and dishes, which have not been used on a given day, may be used later without deterioration in their quality. This is an economic method especially recommended in retail catering.

The durability of products stored in low oxygen conditions may be prolonged several or several dozen times. Beef, when traditionally packed and stored at the temperature of +3-5°C, shows durability up to 3 days, whereas when vacuum packed in the same conditions it is suitable for human consumption for the period of 8 days. Vacuum packaging allows the prolongation of the shelf-life of products stored in cool conditions for smoked sausages – from 7 days to 4 weeks, boiled vegetables – from 2 to 10 days, and tripe – from 2 to 60 days [11]. It should be remembered that the features of the starting product, such as: microbiological quality, degree of fineness, humidity, temperature or the method of thermal processing, to a great degree decide about the durability of the vacuum packed product.

Vacuum packaging prolongs the durability of food products by limiting the development of aerobic bacteria; however, there may develop in these products anaerobic microbes, such as: *Escherichia coli, Salmonella, Clostridium perfringens, Clostridium sporogenes, Lisieria monocytogenes, Staphylococcus aureus* or *Clostridium botulinum*. For this reason, it is recommended that the oxygen content in a packed product should be approximately 2% and additional fixing agents used, such as cold storage or low pH of the environment, below 4.5 [11].

The quality and nutritional value of food subjected to thermal processing largely depends on the conditions of its performance, but also on the method of management after the thermal process. Dishes prepared by traditional methods, after thermal processing, are left to cool at room temperature, until they may be placed in a cold store. During this time, within the range of temperatures from +65°C to + 5°C, the ideal environment is created for the development and proliferation of microorganisms, which reduces the nutritional value of the product (evaporation, leakage) [5].

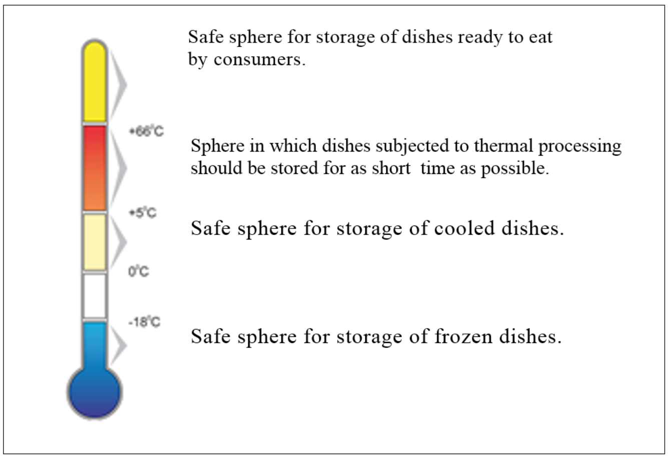

FIGURE 1. Temperature zones for storage of ready-to-eat dishes [5].

Slow, several-hour freezing causes the degradation of the food structure, micro-crystals are formed inside the product which, by rupturing the cell structure of the food, remove mineral salts and nutrients from this food. As a result of dynamic development in food sector, technological solutions which todate have been used only in industrial plants, have also found their way into catering industry in the form of small machines and equipment. At present, the engineering industry offers modern equipment for the shock cooling and freezing of food. Shock freezers are able to reduce the temperature of a dish from +90°C to -18°C inside the product in less than 4 hours, and subsequently maintain dishes at the temperature between -18°C and - 25°C. It should be remembered that during cooling there take place processes of oxygenation and hydrolysis of fats related with the absorption of oxygen. These changes reveal themselves later during the period of storage. An equally modern technique of food preservation using low temperatures is lyophilisation. The organoleptic features of products obtained using this method are much better than standard freezing. The method of quick freezing leads to the formation of fine ice crystals which do not damage the cell walls of the food preserved, and consequently do not cause the leakage of juice from the cells related with this damage. However, according to Kluszczyńska [12], the bilberry fruit preserved using this method showed the lowest antioxidant activity, compared to such methods as freezing or pasteurization.

The sous-vide technology is a technology combining the advantages of vacuum packaging, thermal processing, and rapid cooling of the dish. The advantage of this method is simultaneous application of several fixing agents, e.g. thermal processing, packaging and storage in low temperatures, or cooling vacuum packed products. The nutritional value of the products prepared using the sous-vide technique is comparable to freshly prepared meals due to the elimination of oxygenation of vitamins, colourants, or oxygenation of fragrance compounds. Nevertheless, the sous-vide technique is not perfect, because in the process of pasteurization there may survive and develop during storage psychrophiles and relative anaerobes, such as: *Clostridium botulinum* type E and B, *Listeria monocytogenes, Yersinia enterocolitica,* and *Aeromonas hydrophila* [13].

Thermal food processing

Thermal processing is of crucial importance for the sensory quality of food. It is the precondition for consumption of many raw materials, and it increases the assortment of dishes. As a result of thermal processing, physical, chemical and biochemical processes take place in food, leading to a change of nutritional value, taste and flavour. Nutritional value is usually reduced due to the loss of vitamins and mineral components from the product, or melting of fat. The size of the changes depends on the intensity of the thermal process and its duration [14]. The table below presents the effect of thermal processing on food.

TABLE 1. Effect of thermal processing on food [14].

Positive		
Inactivation	Formation of sensory features	Improvement of digestibility
Microflora and parasites	Colour, taste, flavour and texture	Physical transformations: softening and elimination of semi-permeable membranes, stratification of cells
Thermolabile toxines and enzymes		Chemical transformations: stratification of starch and thermohydrolysis of collagen
		Inactivation of anti-nutritional factors
Negative		
Deterioration of digestibility and reduction of biologial value		
Loss of vitamins	Loss of amino acids	Caramelization of saccharides, formation of Maillard compounds, decomposition of unsaturated fatty acids

The simplest and the safest method of thermal processing of food is boiling. Water environment excellently transfers heat energy which penetrates inside the product, and causes an equal distribution of temperature. Unfortunately, water or other media cause the washing-out of mineral components and vitamins from the product. The size of loss depends on the conditions of performing the process and remains within a wide scope.

TABLE 2. Coefficients of preservation of vitamins related with the preparation of dishes expressed in percentagese [15].

Dish	Process of cooking	B1	B2	PP	B6	C	A	ß-car	E	Folate
Soups	Boiling	0.70	0.90	0.90	0.90	0.50	0.90	0.90	0.90	0.50
Meat Fish	Boiling	0.60	0.80	0.70	0.70	-	0.80	0.80	0.80	0.50
	Frying	0.75	0.90	0.90	0.75	-	0.80	0.80	0.80	0.70
	Baking	0.70	0.90	0.90	0.70	-	0.80	0.80	0.80	0.50
Vegetables	Boiling *	0.60	0.70	0.60	0.60	0.50	0.80	0.80	0.80	0.55
	Frying	0.80	0.90	0.90	0.80	0.70	0.80	0.80	0.80	0.45
	Salad	0.90	0.90	0.90	0.90	0.80	0.80	0.80	0.80	0.95
	Pickled	0.60	0.70	0.60	0.60	0.40	0.80	0.80	0.80	-
Potatos	Boiling *	0.70	0.90	0.75	0.75	0.25	0.80	0.80	0.80	0.50
Pasta	Boiling *	0.75	0.75	0.80	0.80	-	0.80	0.80	0.80	0.50
Rice	Boiling *	0.50	0.80	0.60	0.70	-	0.80	0.80	0.80	0.50
Groats	Boiling *	0.80	0.90	0.90	0.80	-	0.80	0.80	0.80	0.50
Vegetable-meat dishes	Stewing	0.70	0.80	0.80	0.70	0.80	0.80	0.80	0.80	0.50
Sauerkraut-and-meat stew	Stewing	0.50	0.90	0.60	0.70	0.20	0.80	0.80	0.80	0.20
Fruits	Boiling	0.70	0.90	0.90	0.80	0.25	0.80	0.80	0.80	0.50
Milk	Boiling	0.80	0.90	0.90	0.80	-	0.80	0.80	0.80	0.90

* disposing of residue

From the nutritional aspect, boiling of food at an elevated temperature is the thermal process by which the best preservation of the nutritional value of the used raw materials is obtained. Performance of the boiling process at the temperature of 121°C and high pressure of 0.2 MPa shortens the time of thermal processing of broccoli twice, potatoes – 7 times, and carrots – 15 times [14]. Gruzińska [16] reported that uncrushed vegetables subjected to the cooking process in a pressure cooker show a lower loss of nitrates, due to the hindered washing-out of these compounds from the plant tissues. In turn, the cooking of cruciferous vegetables in water results in a higher content of insoluble fraction of dietary fibre than steaming [17]. However, according to Różańska [18,19], steaming, pressure cooking, and cooking in a microwave seem to be the most adequate culinary processes for providing the best nutritional value of meals.

Frying

In gastronomic technology, fats are one of the basic components used in food production. They are a natural component of the raw material, may be added to the dish or used as a heat carrier.

TABLE 3. Content of fat in dishes [20].

Product	Content of fat
Potato chips	20-40%
Potato crisps	30-35%
Doughnuts	20-25%
French fries	7-25%
Fish fillets	10-12%

Considering the high content of fat in fried dishes, the selection of fat and conditions of performing the frying process are important. The basic criterion of the selection of fats and oils for frying should be the composition of fatty acids. Fats characterized by a high content of oleic acid and low content of linoleic acid, e.g. low-linoleic rapeseed oil, are the most suitable for frying. Unrefined fats, e.g. virgin olive oil or cold pressed oils are not suitable for frying considering the high content of free fatty acids and peroxides [20]. The criterion for selecting fat for frying is the so-called smoke point which characterizes temperature resistance, which should be over 200°C. A change of colour of grease during frying, foaming, or the occurrence of smoke, are insufficient to evaluate its usability for further thermal processing. In order to be certain that its further use is safe, a rapid test should be applied for assessing the degree of decomposition of the fat – contents of polar compounds which, according to the regulations, cannot exceed 25%

TABLE 4. Colour tests for the assessment of frying fat [21].

Test	Principle of the method
Fritest	Colourful saponification number
Oxifrit test RAU test Lipid test	Colourful reaction with fat oxidation products
Instant Shortening Test Veri-Fry-FFA 500 SPOT-test	Determination of FFA
Veri-Fri-TAM 150 ACM Quick test	Determination of soaps
TPM **Veri-Fry** Pro	Presence of polar compounds (polymers, oxidized triacylglycerols, FFA, mono- and diglycerides, etc.)

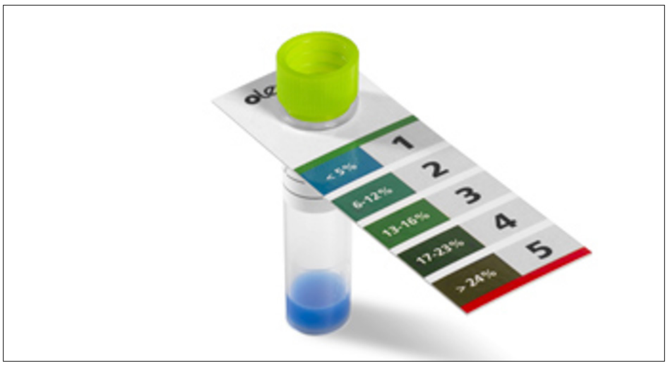

FIGURE 2. Tester of the quality of cooking oil [22].

TABLE 5. Smoke point temperature of selected plant oils [23].

Oil	Smoke temperature, °C
Rapeseed	242
Sunflower	240
Soya	234
Corn	234
Refined olive oil	220
Virgin olive oil	166

Apart from the proper selection of fat, the conditions of performance of the frying process are of great importance for the quality of the dish, its organoleptic properties and nutritional value. During frying, there occurs shrinking of the product, and substances soluble in fat are released to the environment, such as colourings, flavourings, and fats contained in the dishes. Insoluble compounds also penetrate into fat, such as, batter and various coatings, which cause darkening and accelerate unfavourable transformations in the fat.

TABLE 6. Scope of transformations and factors causing decomposition of fat [20].

Types of transformations	Catalyzing agent	Reaction products formed
Oxidation and oxidative polymerization	atmospheric oxygen	- volatile compounds (aldehydes, ketones, acids, alcohols, hydrocarbons, etc.) formed as a result of rupture of fatty acid chains; - macromolecular non-volatile compounds, remaining in the frying grease, containing various functional groups (alcohol, ketone, epoxide, and others), which are monomers or polymerised to dimers, trimers, and higher polymers
Hydrolysis	water, water vapour	- free fatty acids, diacylglycerol, monoacylglycerol, glycerol.
Thermal transformations including polymerization and cyclization	high temperature	- cyclic compopunds formed from polyunsaturated fatty acids; - fatty acids triacyloglycerol dimers and polymers

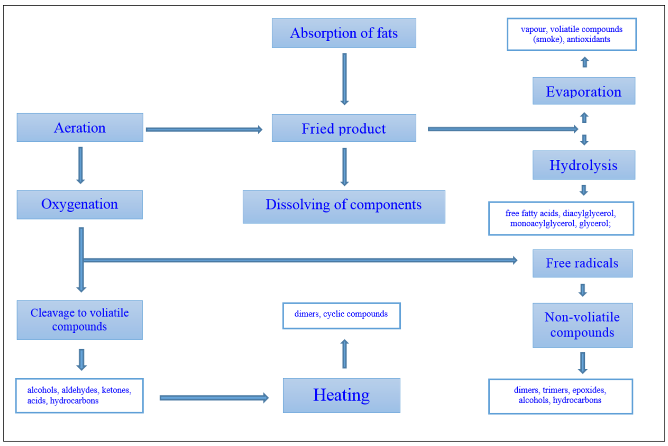

FIGURE 3. Transformations taking place during frying of products [20].

Attempt to draw conclusions

Summing-up, in the light of the specificy of the contemporary health situation in countries with a high level of civilisation development characterized by the domination of NCD as a leading cause of mortality, modern gastronomic technology/culinary art faces the challenge of simultaneous meeting social expectations which are sometimes diverse, concerning, on the one hand, aesthetic dining experiences, and on the other hand, effective prevention of contemporary health hazards. In both areas, the latest achievements of science and engineering are applied: they are used in order to provide the consumers with attractive aesthetic experiences (in this context, Jose Miguel Aguilera [24] uses the term *techno-emotive cuisine*), as well as to achieve prevention goals, among which the priority is striving for the production and popularization of food with low calorie density, but attractive from the aspect of taste, which would be a tempting alternative for so-called 'junk food', and also the introduction of bioactive components beneficial for human health into food and its preservation [24]. The importance of the approach defined by the term '*science-based cooking*' is evidenced by the fact that during the implementation of educational programmes concerning human nutrition and dietetics at Harvard University, in order to make progress in the area of culinary art more dynamic, cooperation has been started between outstanding chefs and representatives of science [24]. It seems that the challenge for contemporary gastronomic technology remains the working out and practical application of approaches which are the synthesis of the requirements of modern culinary art, and the principles of NCD prevention. Obviously, this task cannot be perceived in isolation from the assumptions of 'new public health' (NPH), which pay attention to the importance of multi-sector cooperation as a key instrument for modern health promotion. At the same time, this is a precondition for its effectiveness in the modelling of health conditioning, as indicated by experiences from the North-Karelia Project. In the light of this project, the obtaining of measurable health effects on a population scale, concerning mortality due to cardiovascular diseases, was possible due to the inclusion of non-medical sectors into actions in the area of prevention and health promotion. This also resulted from pro-health changes in the Finnish sector of food production and processing [25,26]. Therefore, it seems justifiable to engage the medical sector and food industry in long-term actions aimed at the gradual and permanent change in the eating habits which would lead to the decrease in morbidity due to NCD.

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