The Role of Food Physics in Fulfilment the Expectations of Up-to-Date Food Technologies and Biotechnologies to Use a Well Balanced Nutrition

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Abstract: The paper deals with some topics of important aspects of food safety and application of principles of food physics in the sector of agriculture, food technology, biotechnology, including questions of well balanced nutrition, as well. One of the most important and widely applied field of biotechnology is the food technology. Food production and processing of quality food and safe food are today of primary importance. Food production is based on the principles of GAP, GMP and GHP. Recently the industrial food processing is focused dominantly on the quality, and one of the basic requirements of the quality is the safety.

There are various methods and techniques to produce safe food. The modern food technologies and quality measurements (quality control, quality assurance) involve the application of different physical methods – e.g. high pressure, pulsing electrical field, nondestructive techniques (e.g. NMR, NIR-NIT, PAS, INAA) for chemical composition determination, radiation techniques, nanofiltration and reverse osmosis (RO) – as well. Using e.g. ionizing radiation (nuclear methods) and non-ionizing radiation technologies it is possible to fulfil a lot of important expectations: decrease of microbial contamination, improve of sensory properties, increase of storability, etc.

The paper deals with questions of up-to-date, with sport motion combined diet, helping in keeping the health, as well. In the last decades a lot of information were distributed concerning several viewpoints of bodyweight reduction and optimation of bodymaa. How should we know that it is useful and not unhealthy? A suitable Nutrition software (AOPNEI, Analysing and Optimation Program for Nourishment and Energy Intake) – developed at the Department of Food Chemistry and Nutrition of the Faculty of Food Science, Corvinus University – can help.

Keywords: Bodymass, food processing, food safety, physical methods, quality assurance, nutrition, radiation methods.

INTRODUCTION

Food industry – which is practically the most dominant part of biotechnology - is based dominantly on agricultural production. No questioin, that today the processing and production of quality food is of primary importance, although the meaning of safe food and quality food is of course not the same! Quality food should be safe, but safe food – in some cases - can be not really a quality one (e.g. not satisfactory sensory properties.) So safety – naturally we should accept this factor in the whole food chain, from farm to fork - is only one requirement of the quality, concerning the agricultural production, food processing, industrial or kitchen-technique production and consumption, as well. And the application of various physical methods and techniques is one of the possibilities to produce safe food with acceptable (reasonable) price and using environment-friendly technology.

MODERN FOOD INDUSTRY: QUALITY AND SAFETY OF FOOD PRODUCTS

Safety is a basic requirement, meaning no harmful effects from the food, eaten by humans. The next parameter is the value of pleasure (sensory properties of the food) and there are some other factors (quantity, volume, chemical composition, packaging, labelling, special – microbiological, toxicological, radiometrical – parameters) determining the quality of the different food products.

Of course the sensory parameters (e.g. delicious taste, favourable colour) have an extraordinary importance, proven even by the sequence of the quality measurements, as well. First (before the chemical, physical, microbiological mesasurements) we should carry out the organoleptic investigation of the food products, and if the parameters are not satisfactory there is no need for any other measurement.

Quantity and/or volume can be also an important factor for characterization of the quality, e.g. if the mass of the product on the label is 250 g, but the real mass is only 240 g, the product is not acceptable.

In many cases the quality problem of the food products is related to the chemical composition, e. g. too high amount of salt or water or fat (even trans fatty acids), or too low concentration of dry material, protein or vitamins. The nutrition biological value is always based on the chemical composition and this can be

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measured by various analytical (including a lot of physical) measuring techniques.

Nice, interesting and safe packaging with correct labbelling is also important (protection and information).

And the last factor is of course mainly in rather close connection with the basic requirement (safety), proving that e.g. there are no pathogen microorganisms, toxic heavy metals or radionuclides or pesticides in the food product, or the concentration of these materials is negligable/acceptable.

FOOD PROCESSING AND FOOD QUALITY CONTROL

Modern food production is based on principles of GAP, GMP, GLP and GHP.

GAP - Good Agricultural Practice

GMP - Good Manifacturing Practice

GLP - Good Laboratory Practice

GHP - Good Hygiene Practice

Quality control and quality assurance are based on principles of HACCP (Hazard Analysis Critical Control Points), ISO-9000 standards (International Standards for Quality Management), TQM (Total Quality Management) and IFS (International Food Standard). The components of quality assurence are shown in Figure **1** [1,2]. The quality management concepts are as follows: identify the needs and expectations of the customers and decide how to fulfil these needs [3].

FOOD PHYSICS AS A CONNECTING BRIDGE BETWEEN APPLIED PHYSICS AND FOOD SCIENCE

The term “food physics” is not known enough in spite of the fact, that the constituent words (food and physics) have been used for thousands of years. Food physics is of course a part of food science, but belongs to applied physics, as well [4-6].

Development of different branches of science and creation of new fields can be explained basically in 2 ways: differentiation and integration. (Anyway, let us mention that of course classification of the different branches of science and differentiation/separation of the various fields is of artificial character. Because in the nature there are no borders between the different sciences, science is a continuous and correlated body of knowledge. However for the sake of human brain – of course with limited abilities – differentiations and integrations are established and developed, and these separations and different directions are mainly based on the extremly rapid increase of knowledge.)

Figure **2** shows the really important sub-branches of food science and applied physics [5,7-9]. Technical sciences we understand here as engineering. Obviously the development of food science and applied physics is influenced by the development of many other scientific branches, e.g. technical or agricultural

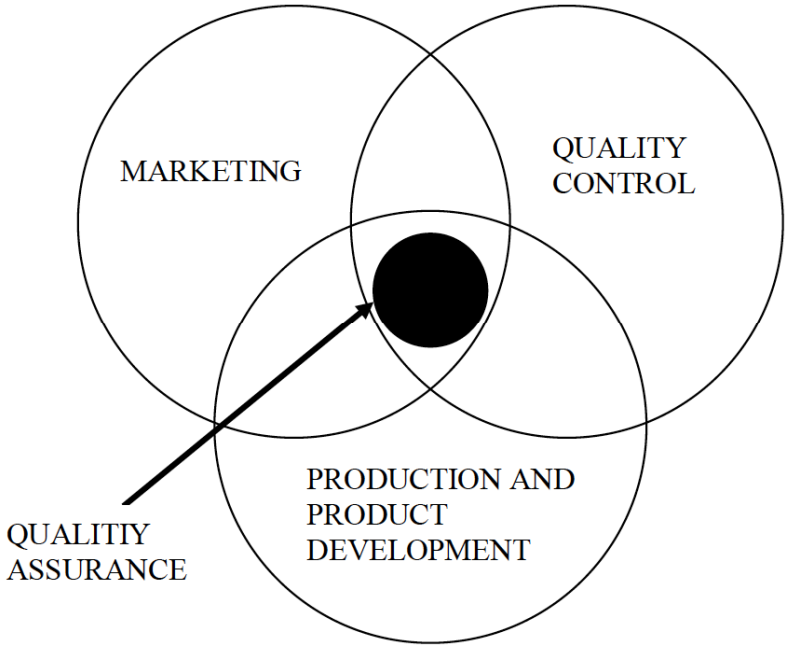

Figure 1: The components of quality assurance.

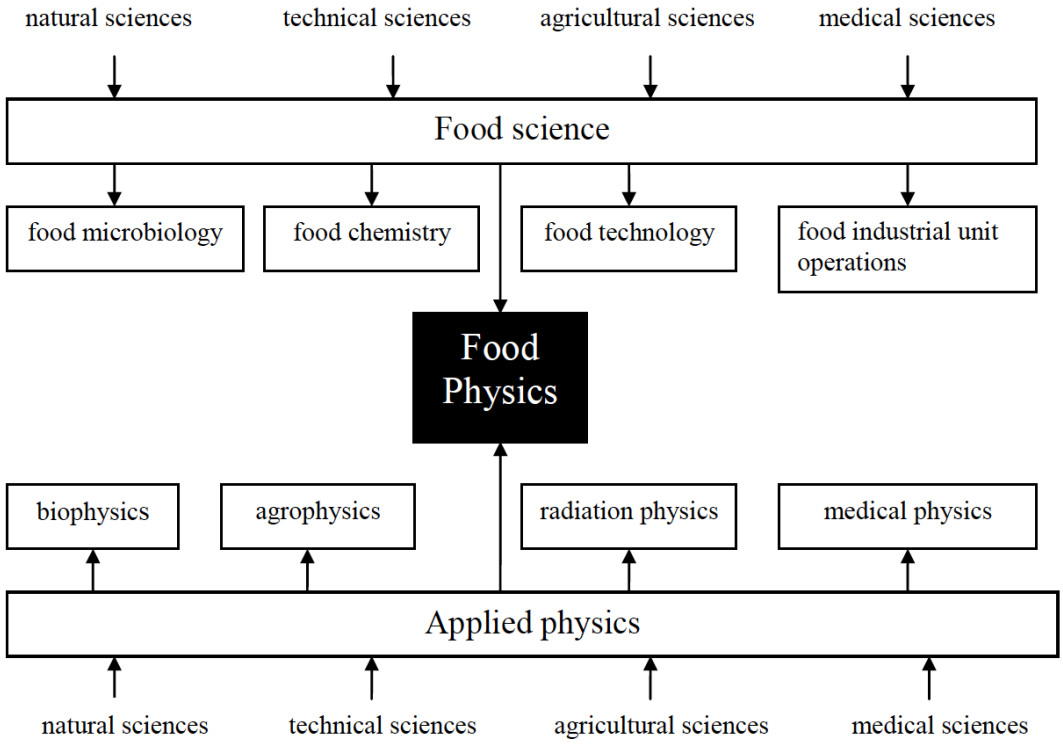

Figure 2: Sub-branches of food science and applied physics.

sciences, as well. Food physics is a strong and solid connecting bridge between food science and applied physics.

Because there is no sharp dividing line between natural sciences (physics, chemistry, biology) obviously there are correlations also between some chemical and physical (and even organoleptical) parameters of foodstuffs and agricultural products [10]. Measurements of food products prove, that there are significant relations between chemical components and structure (physical forces), between structure and physical properties (mechanical apparatus) and between physical properties and texture (sensory apparatus). E.g. the result of relations between rheological measurements and sensory evaluation tests of foodstuffs can be a very interesting matter, and useful one both for processing and control.

Let us mention that some of the principal branches of physics find application in food production and research, e. g. dielectrometry, refractometry, polarimetry, scanning electron microscopy (SEM), mass-spectrometry (MS), NMR (nuclear magnetic resonance) spectroscopy, ESR/EPR (electron spin resonance or electron paramagnetic resonance) spectroscopy, microwave technique, thermal analysis, X-ray diffraction, absorption spectrophotometry in infrared region, fluorescence analysis, authoradiography, viscosimetry, sonics and ultrasonics have been used in various ways of food processing and quality control [11]. These techniques – wit supplementation of some other new methods, like PAS (photo-acoustic spectroscoppy), NIR (near infrared reflectance), NIT (near infrared transmittance) and DSC (differential scanning calorimetry) – are applied also in R+D (research and development) of biotechnology and food processing. The physical knowledge (e.g. thermodynamics, mechanics, optics, acoustics, electrodynamics, electrostatics) is important of course in the education of food technologists and food engineers, as well [12].

Food physics – as a rather new field of science – is a special, but typically interdisciplinary subscience [13,14]. The 3 main topics of food physics are the following [15-18]:

- physical parameters (e.g. rheological, electrical, optical, radiometrical, thermal parameters) of foodstuffs
- physical methods (e.g. NMR, ESR, NIR-NIT, PAS, DSC) for investigation of foodstuffs
- physical methods and techniques (e.g. filtration, reverse osmosis, freezing, irradiation, high pressure pasteurisation, dehydration, microwave

treatments, ohmic processing, pulsed technologies) for treatment and processing of foodstuffs

If we use the term „food physics" with a little wider interpretation, food physics will of course cover a dominant part of the R+D activity of food industry, because the fundament of measuring technique, control, mechanisation, instrumentation, automation and even robot-technique and op-to-date technologies, like nanotechniques is the same: physics.

From point of view of applied physics it is possible to define the term „food physics" as a sum of physical methods, techniques, technologies and processes, applied in the food industry, in the food sector. In other words, food physics – as compared to fundamental sciences – is a typical applied sience, trying not only to cover, but also to solve the problems of practical life (within the food sector, of course).

There is a possibility to use also the term „food" in a wider sence, not only for definitely final food products, but also for raw materials, agricultural products, additives etc., so all the materials, substances which are necessary for food processing and production. In this case some parts of agrophysics – this is also a typical frontier field, an interdisciplinary subscience – belong to food physics.

PHYSICAL METHODS IN THE VARIOUS FOOD TECHNOLOGIES

No doubt, modern food technologies and food measurements are based dominantly on the principles of physics. Let us mention some physical methods and nondestructive techniques (instrumental analytical ones), which are suitable, effective and widely used in food engineering and food quality control:

Processing methods:

- dehydration, drying
- crystallization
- homogenization, mixing
- chilling
- freezing
- heat treatment by ohmic processing
- heat treatment by microwave processing
- distillation
- evaporation
- filtration (including microfiltration, ultrafiltration, nanofiltration, RO)
- lyophylization
- high pressure
- pulsing electrical fields
- magnetic fields
- irradiation (ionizing and non-ionizing techniques) for preservation

Techniques for measurements and investigations:

- optical non-destructive and non-invasive techniques (e.g. NIR-NIT, PAS, fluorimetry)
- magnetic non-destructive and non-invasive techniques (e.g. NMR, ESR)
- radioanalytical non-destructive techniques (e.g. INAA, instrumental neutron activation analysis, XRF (X-ray flourescence), PIXE (particle induced X-ray emission)
- rheological techniques (e.g. penetrometry, plastometry, viscosimetry)
- thermical techniques (e.g. thermodilatometry, thermometry, DSC)
- electroanalytical non-destructive and non-invasive techniques (e.g. dielectrometry, oscillometry)

RADIATION METHODS IN THE AGRO-FOOD SECTOR

Different radiation methods are widely used in agricultural and food production, food quality control, covering many fields of the whole food sector (Szabo, 1992, 1993). These are the following important techniques or technologies, having close conncection to the fields of food physics:

- Ionizing (nuclear) radiation techniques and technologies (e.g. gamma-sources, X-ray equipments, electron accelerators, reactors)
- Non-ionizing (non-nuclear) radiation techniques (e.g. light-technique, IR, UV, Laser, AGROLUX,

STIMOKOMPLUX, SYNERGOLUX: UV+ozone, polarized light)

- Irradiation treatments for food, feed and waste materials
- Radiostimulation technique
- Radiomutation technique
- Male-sterile technique
- Radioisotope techniques, tracer techniques
- Radio-analytical techniques (e. g. AA, activation analysis)
- Radio-immuno-assay techniques (RIA)
- Nuclear filters (membranes produced by nucler techniques) for control and processing
- Nuclear measurement techniques (for determination of quantity, level, thickness etc.)
- Radioecological measurements
- Investigation of migration, transfer of natural and artificial radionuclides in the complex biological (food) chain
- Radiocontamination, decrease of pollution, radiodecontamination

EXPECTATIONS IN MODERN FOOD PROCESSING TECHNOLOGY

The requirements of the up-to-date food production are mainly the following:

- Decrease of the microbial contamination, disinfection
- Increase of the storability of products
- Improvement of the sensory properties
- Apply environment-friendly and economical technique

Let us mention – not going into details – that application of some radiation technologies is really favourable and effective, concerning these requirements. Of course if we speak about application of different radiation techniques, we should differentiate between ioninzing radiation and non-ionizing radiation based on the energy of the radiation. In case of ionizing radiation (e.g. gamma-sources, X-rays emitting equipments) we need a special shield for radiation protection, as well, which is not necessary in case of non-ionizing, non nuclear radiation (e.g. UV-light) technique.

Huge amount of measurements were carried out to investigate the effect of special light technique treatments (AGROLUX, SYNERGOLUX technique using equipment with UV radiation and ozone treatment) on the preservation (storability) of different vegetables and fruits (e.g. cucumber, cauliflower, beans, tomato, spinach, green paprika, apple, kiwi) [19-26]. During the storage time enzyme activities (PME, MDH), mass decrease and sensory parameters were determined and rheological (fructometric) mesurements were carried out, for optimation of the treatment conditions. The treatment with optimum dose had favourable effect on the storability, mass-decrease, organoleptic and rheological parameters. The positive effect of light-technique treatment was proven by microbiological investigations of dried vegetables as well [27].

HEALTHY DIET, ADEQUATE NUTRITION

From point of view of healthy status of the organism and estetic appearance of the human body the bodymass should be rather close to the ideal (optimum) one. With high probability the optimum bodymass will have a favourable effect not only on the quality of life, but on the life-expectancy, as well. And in case of sport activity, the optimum body composition is one of the most important parameters, determining the performance level of the athletes. Concerning this field, we would like to give information about 2 topics:

- necessity of combination of the adequate nutrition and sport activity (eating, optimum body composition and physical load)
- computer sofware as Analysing and Optimation Program for Nourishment and Energy Intake (AOPNEI)

Let us mention a few useful books and papers, covering the field of adequate nutrition, bodyweight reduction, health and physical load [28-36].. In the International Scientific Journal of Kinesiology (SSPA) some interesting papers were published concerning the complex topics of nutrition and sport. Görner at al. [37] were dealing with questions of physical activity, bodymass and body composition, in the paper of Sunje [38] information was given about menus for athletes

and Nasim [39] paid attention to topic of effect of aerobic exercise in case of obese women.

UP-TO-DATE DIET – WELL BALANCED NOURISHMENT

Adequate nutrition means to eat not more and not less than the real physiological need of the organism. Of course the need is a function of many factors, e.g. gender, bodymass, age, type and duration of physical activity, body-composition, climate. To avoid the overweight and obesity we need moderated nourishment, not forgetting, that recently in developed countries (based on BMI determinations) appr. 30-40 % of adult population is in obesity state (BMI is over 30). Therefore the up-to-date diet – based on the newest achievements of nutrition science, as well – requires really moderated, but in the same time well-balanced nourishment. Well-balanced diet is adequate for all essential (biologically important) components of nourishment, e.g. for protein, indispensable fatty acids, macro- and microelements.

Using internet you can easily find huge amount of pictures about diet pyramids. Figure **3** shows one f the pictures of the healthy diet pyramid (www.nutrition.com.sg.) This is not a rigid prescription, but a general guide for normal human beings, that lets you choose a healthful diet that is right for you. Anyway, in case of top athletes we need some significant modifications (e.g. application of food supplements), because the pyramid was constructed not for top competitors. This type of pyramid has 5 different (basic) groups of food products.

The top level (small tip) of the pyramid shows fats, oils, sugar and salt. These are foods such cooking oils, butter, margarine, sugars, sweet desserts, seasonings and sauces. These foods provide dominantly calories (energy) and little else nutritionally. Most people should use them sparingly.

On the next level of the healthy diet pyramid are foods that come mostly from animals: meat like beef, lamb, mutton, pork, poultry, meat products, fish, eggs, milk, yogurt, cheese; nuts and seeds. These foods are mainly for protein, fat, calcium, iron, and zinc.

The lower level includes foods that come from plants, these are vegetables and fruits. Most people need to eat more of these foods for the vitamins, minerals, and fibre they supply.

At the base of the diet pyramid are rice and alternatives like noodles, breads, cereals, pasta - all foods from grains. In general your daily meals should include largest number of servings of these foods each day.

DETERMINATION OF THE OPTIMUM ENERGY INTAKE

If the person – e.g. with too high fat-ratio of the body – has overweight, the successful diet should be based on negative energy-balance. It means, that the energy-intake should be less, than the consumed energy by the body. The difference can be based on the mobilization of fat-depo. The determined daily energy intake is always individual, depending on the basal metabolic rate (BMR) and other parameters.

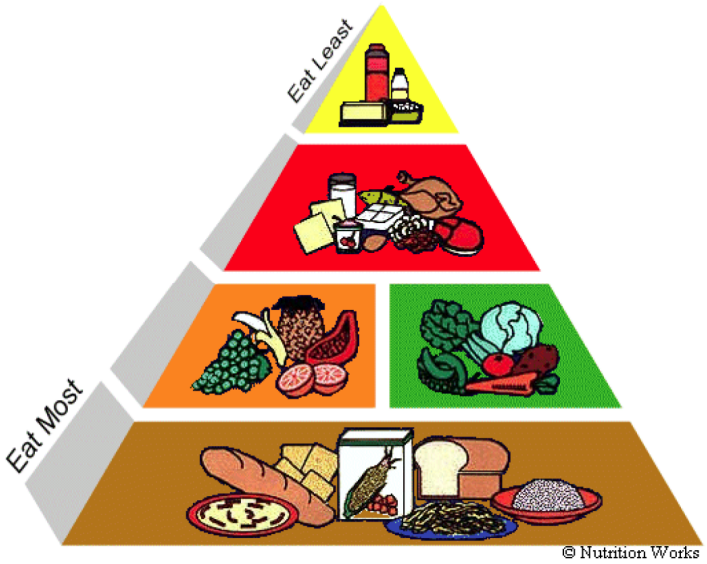

Figure 3: Healthy diet pyramid.

To the sophisticated scientific literature in case of long-term weight-reduction the optimum daily energy-deficiency in general is not more than 500-600 kcal (2000-2500 kJ). For normal people this is in general a daily diet with 1200-1500 kcal (5000-6300 kJ) for female, and 1400-1800 kcal (5900-7500 kJ) for male individuals. As we mentioned, in case of weight-reduction (e.g. too high fat% of the athlete) the successful diet is based on negative energy-balance. But the long-term fat-content decrease of the body should not exceed 50 g daily, which is appr. 1.5 kg kg/month. So for 10 kg real bodyweight-reduction (not water, but fat should be removed) we need 6-7 months period as a minimum.

DAILY ROUTINE OF NOURISHMENT INTAKE, PERIODIZATION OF MEALS, VARIABILITY

The proposition is 4-5 meals/day – in some cases even 6 meals: breakfast, second breakfast, lunch, high tea, supper and additional evening meal (e.g. cup of yogurt) before going to sleep – of course in moderated quantities, trying to keep the level of insuline almost constantly and helping the decrease of the bodymass [40].

The task is to create and apply a varied, many different foodstuffs containing, diverse diet which is in harmony with the individual tastes and habits. Of course one has to take into consideration the propositions of healthy diet pyramide, as well.

MOTION, PHYSICAL ACTIVITY, SPORT

Healthy life-style involves not only well-balanced nutrition, but physical activity, as well. Systematic and regular sport activity has a lot of favourable effects, beneficial advantages, because it is not only an effective help in keeping the normal bodyweight, but increases the muscle-ratio and decreases the fat-ratio of the body, improves the cardio-vascular ability of the organism, enhances the endurance, and based on these effects significantly decreases the risk of illnesses. In other words: effectively improves the quality of life, producing wellness and fitness.

It is proved, that the intensive motion slightly increaes also the BMR, the favourable effect is detectable after the training, as well, and the regular physical activity increases the fat-burning capability of the body, as well. Another positive advantage is the stress-decreasing effect, decreases also the pressure of eating and it is a pledge of a good and deep sleep. The question is the following: what should be the intensity of the motion? We can choose a high, or medium or low intensity sport activity.

In case of high intensity the duration of the exercises (e.g. sprint, weightlifting) is short. This type of training does not influence the fat-mobilization of the body, but increases the muscle-strength.

Spesaking about medium intensity sport activity the duration of the exercises (e.g. running, tennis, swimming) is longer, this type of training increases the endurance. Such exercises and trainings increase the fat-burning, but protect the muscle-mass. 3-5 minutes after the beginning of the motions the fat-stream from the fat-depo of the organism into the blood is measurable, but the fat still does not burn, because for this we need much longer time. To the newest knowledge of the specialists the biggest amount of fat will be burnt at medium intensity sport activity between the 30 and 90 minutes of the training. We mention that this type of training is the most effective tool on the reduction of fat layer thickness on the waist.

The low intensity exercises (e.g. walking, jogging) stimulate the release of fat from fat cells. Because of the rather low level energy consumption of the organism the carbohydrate consumption is also very moderated, the need is mainly covered by the sugar in the blood.

ANALYSING AND OPTIMATION PROGRAM FOR NOURISHMENT AND ENERGY INTAKE

At the Department of Food Chemistry and Nutrition of the Food Science Faculty of former Corvinus University, Budapest, Hungary (today the Faculty belongs to the Szent Istvan University, Gödöllő) a special, interactive software – computer program for planning of nourishment – was developed (AOPNEI), which is suitable for planning and control of the nutrition of various people, including even top competitors, as well (Tolnay *et al*., 2012).

The software is composed on 4 Excel files, which operate statistically evaluated and fitted algoritms, representing the model as a logical system. With help of the AOPNEI software the propositions (real energy and nourishment demand) are determined based on the following parameters: gender, age, bodymass, height, level of physical activity and other anthropometrial - shoulder, hip, waist, wrist, elbow, skin caliper at biceps, triceps, breast, back, front (belly), inside and outside thigh (leg) - and physiological - body temperature, bodyfat %, BMI, puls (heart frequency)

after wake up – characteristics. It is possible to take into account the differences in the metabolism of the investigated persons, as well. The databank of the software contains 90 chemical composition parameters (e.g. starch, fat, dietary fibre, water soluble vitamins, essential macroelements) for more than 1000 basic food, foodstuffs and diets, so the calculations are based on more than 90 thousand data. Using this database it is possible to create special recipes for the individuals.

Based on the results of the previous measurements (input data) and the databank the process for optimation of bodyweight can be performed. For effective and appropriate calculation we should put still the following information into the computer: measure of the bodymass change (kg) and the planned time interval to reach the wanted (or optimum) bodymass. The sofware will calculate also the individual puls rate interval, which is useful for effective fat-burning. The parameters, evaluated and calculated in the program are shown in Table **1**.

Table **2** shows the different groups of food products. To our classification 15 different groups of foodsuffs were constructed and evaluated, significantly more than shown in the diet pyramid. Concerning the level of physical activity – e.g. recreational level activity or high load in top sport – 2 versions were elaborated. The first one is a simple model for normal, everyday, recreational level physical activity (e.g. 30 minutes jogging/per day), the second one is more complicated. This version needs the planned or performed physical activity precisely for 24 hours of each day. On the base of information about the physical activity (sport branch, level of intensity, duration) the program will determine the physical activity factor and the energy requirement for the performed sport activity, as an additional need.

Table 1: Evaluated Parameters of the Program

BMI index, bodyfat %, proposed optimum bodymass (kg)
physical activity factor, ideal puls rate interval for fatburning
energy requirement of basal metabolism (BMR), energy requirement of real (working) metabolism, need of energy balance (kcal, kJ)
energy intake, energy deficiency or energy excess (kcal, kJ)
protein requirement, total protein intake, intake of protein of animal origin, protein deficiency or protein excess (g)
proposed carbohydrate intake, real carbohydrate intake, added saccharose intake, deficiency or excess of carbohydrate, glicaemic index for different meals (%), glucose load of the different meals (g)
fat requirement, total fat intake, vegetable oil intake, deficiency or excess of fat (g)
dietary fibre requirement, intake of dietary fiber, deficiency or excess of dietary fiber (g)
water requirement, water intake, deficiency or excess of water (l)
maximum tolerable alcohol intake, real alcohol intake, alcohol excess (g)
sodium intake, sodium excess (mg)
potassium requirement, potassium intake, deficiency or excess of potassium (mg)
calcium requirement, calcium intake, deficiency or excess of calcium (mg)
magnesium requirement, magnesium intake, deficiency or excess of magnesium (mg)
ratio of (Na+Ca)/(K+Mg), ratio of Ca/P
iron requirement, iron intake, deficiency or excess of iron (mg)
quantities of intakes of different food groups shown in table 3 (dkg)
energy intake from different food groups (kcal, kJ)
percentage (%) of the diffrent meals from the total daily energy consumption
percentage (%) of the food components of the total energy intake
energy utilization based on the different physical loads (e.g. sport activity) of the body (kcal, kJ)
protein, fat, carbohydrate, dietary fiber, Na, K, Ca, Mg, Fe intake from different food groups (g or mg)
estimation of need, intake, deficiency and excess of vitamins A, D, E, C, B-1, B-2, B-3, B-6, B-9 B-12 (mg)
estimation of need, intake, deficiency and excess of Cu, Zn, Mn, Cr (mg)

Taking into consideration also this additional need, the program will have a proposition for the daily nourishment. With this program we can plan, calculate and control the daily nourishment for long period or even evaluate our previosly applied diet.

Table 2: Groups of Food Products (Food Groups in the AOPNEI Software)

milk
milk products
meat, fish, meat products
egg
bread products
other cereals (e.g. rice)
vegetables, greens
fruits
nuts, oil-containing seeds
confectionary products, sweets
fats, oils
non-alcoholic drinks
alcoholic drinks
food supplements
other products (e.g. added sugar)

CONCLUSIONS

Food physics is not only a rather new field of a fast developing subscience (and a typical interdisciplinary science), but a strong and solid bridge between applied physics and food science, as well. It is evident, that modern biotechnology, food processing (and food quality methods) badly need the help of physics, both for production and quality assurance. The importance of application of physical techniques (for processing and control with non-destructive measurement methods) will definitely increase in the future, and using these modern physical methods we can fulfil the expectations of up-to-date food technologies, producing safe, high quality food with reasonable price.

The real (adequate) energy and nourishment requirement of the human body depends also on the physical activity of the individuals. So, in case of determination of physiological need of the organism we should take into account the physical activity factor, as well. The up-to-date diet is always well-balanced, moderated and varied, based on many different foodstuffs. Applying the developed AOPNEI software we can plan and control the daily nutrition of persons, as a function of many parameters. The application of the program is suitable not only for control the nutrition, but can help in modification of life style, way of life, in prevention and treatment of deficiency diseases, too. In other words to produce better quality of life and healthy status.

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