INTELLIGENT TECHNOLOGIES FOR THE RISK ASSESSING IN THE CHAIN OF AGRICULTURAL PRODUCTION

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Abstract. The rapid alert system for food and feed (RASFF) provides rapid information on newly identified risks to the consumer. In this article the main results of new intelligent technology for the risk assessing in the chain of agricultural production are discussed. In EU there is a place for traditional agricultural products, foods and local specialties. It protects distinctive or traditional foods associated with certain regions or certain production methods from being unfairly copied by others, and it promotes organic farming.
The agricultural product's properties, which have to be identified and fixed for the risks assessment to the consumer by means of measuring devices, can be so different that there can be no "essence". Therefore on the basis of modeling of "intellect of consumer" a new intelligent electronic device "artificial tongue" Logicor-AT for risk assessing in the chain of agricultural production has been developed.

Key words: risk assessing, intelligent technologies, rapid alert system, consumers protection.

Introduction

The risk assessing is the scientific precautionary process. Therefore, before taking a policy decision about whether a food or feed product is safe to eat or whether to allow a particular ingredient or additive, the EU looks at the scientific advice. In managing the risk, the EU applies the 'precautionary principle': if there are reasonable grounds for suspecting there is a problem, the Commission acts to limit the risk. It does not necessarily need to wait for proof that there really is a risk. Of course, this principle must not be wrongly used as an excuse for a protectionist measure. Where the scientists have not conclusively established what the nature of the risk is, they must at least have identified potentially dangerous effects before the Commission can justifiably use the precautionary principle to take measures relating to a feed or food product. Any action the Commission takes must target only the potential risk. It must be non-discriminatory – in other words, it must affect all producers equally. It must be based on an examination of the costs and benefits of action and failure to act, and must be provisional while work continues on obtaining greater scientific certainty. Funding research food safety and biosensors industry is steadily growing. In the interests of risk science, EU spends tens of millions of euros annually on finding new ways of preventing or detecting more quickly outbreaks of animal diseases, and supporting work on new and better crops. There is a €685 million budget solely for food quality and safety research between 2002 and 2006 [1-3]. This money is primarily going into investigating: when and where food-related diseases and allergies occur most, the relationship between food and health, traceability along the food chain, methods of analysis, detection and control of threats to food safety, safer and more environment-friendly production methods and technologies, healthier foodstuffs, the way in which animal feed can ultimately affect human health, and the role of environmental factors in health.

Safe Food for Consumers

Food safety is a top priority in Europe. The EU's demanding rules have been further toughened since 2000 to ensure that Europeans food is extremely safe. The new approach is more integrated: feed and food are carefully tracked from the farm to the fork. EU authorities carefully evaluate risk and always seek the best possible scientific advice before banning or permitting any product, ingredient, additive or GMO. This applies to all feed and food, irrespective of whether it comes from inside or outside EU. Safety does not mean uniformity. EU promotes diversity based on quality. European law protects traditional foods and products from specific regions by ensuring consumers can distinguish them from copies. The European Union is increasingly encouraging its farmers to focus on quality – not just in food but also in the rural environment. EU also respects the consumer's right to an informed choice. It encourages public debate, it requires informative labeling and it publishes the scientific advice it receives, so that consumers can have confidence in the food they eat. The first rules on food safety date from the very early days of EU. The food safety crises of the 1990s showed it was time to replace what had become a patchwork of rules with a simpler and more comprehensive approach. The new approach also paid closer attention to the risks from contaminated feed. The result was a new piece of 'umbrella' legislation known as the General Food Law, to be phased in between 2002 and 2005. This law does not only lay down the principles applying to food safety. It also introduces the concept of 'traceability'. In other words, food and feed businessses – whether they are producers, processors or importers – must make sure that all foodstuffs, animal feed and feed ingredients can be traced right through the food chain, from farm to fork. Each business must be able to identify its supplier and which businesses it supplied. This is known as the 'one-step-backward, one-step-forward' approach. It set up the European Food Safety Authority (EFSA) to bring under one roof the work previously done by a range of scientific committees and to make the scientific risk assessment process more public. It also reinforces the rapid alert system, which the European Commission and EU governments use to act quickly in the event of a food and/or feed safety scare. Producers and processors must also comply with a large number of rules on specific issues. The point of all these rules is to make sure that food is as safe as it is technically possible, to keep consumers informed and to give them as much choice as possible. Depending on the issue, this can mean that EU adopts a single set of standards or that the member states agree to recognize each other's standards. Differences in detail may not matter if the end result is the same.

In the past, many companies assumed that the quality of their raw materials could be guaranteed simply by paying the highest prices. However, this did not prove to be very reliable and almost all firms now use various analytical methods for quality determinations. For a short time in agriculture even more often biosensors are applied for quality control of agricultural products. The biosensors industry is new but growing. The overall food product testing industry is growing steadily. For example, the US food industry performed around 144.3 million microbiological tests annually, as shown in Table 1.

Table 1

US Food Industry Total Tests per Sector (USDA, Strategic Consulting)

Sector	Number of Plants	Total Tests	Average/Plant/week
Beef and Poultry	1,679	32,212,471	369
Dairy	1,388	45,887,576	636
Fruit/Vegetables	652	13,981,305	412
Processed foods	2,260	52,196,282	444
Total	5,979	144,277,634	464

The market is generating a need for sensors across all segments. The specific testing market is expected to grow for all segments at a compounded annual growth rate (CAGR) of 4.5% with a total market value of $563 million by 2003. In the sensor market today, the consumer has to make a choice between time and sensitivity better than 100 CFU/mL. The market is comprised of four segments – medical, environmental, food, and military. Ninety percent of sales come from glucose – detecting biosensors for medical applications. The market is generating a need for pathogen detecting biosensors across all segments [1, 4, 5].

Quality control ensures that raw materials meet set standards, processing methods perform as designed, finished products meet company standards, and consumer confidence in the company remains high. Problems arise when there is disagreement on what is actually required to ensure safety. Another important area of standardization relates to the information presented to the consumer. In this case it is not the product itself, but rather its description that must conform to a particular standard. Much effort has been devoted to harmonizing labeling information and very large market segments do have common requirements. There may be some disputes arising out of a culturally-based philosophy regarding the role of food in the diet. Some societies traditionally confer great health benefits to certain foods while others may not. This may lead to health claims that are allowed in one country and not in another. Industry standards are sometimes established by an organized industry association in order to establish a reliable identity for a particular product.

Intelligent Technologies for Assessing Risk

Intelligent techniques for measuring human sensory response to food texture have been undertaken since 1980s to study relations between physiological and sensory testing of perception.

Since the half of the eighties the technological mimic of the main functions of human olfaction became possible. Since that, an increasing number of researchers have dedicated their efforts to improve the original idea pursuing the fabrication of electronic tongue. Practical applications, in a wide number of cases, appeared in the literature, and in the nineties some companies have introduced the electronic tongue technology to the market. Recently in food industry and in agriculture for quality control of agricultural products are even more often applied sensors. Much research was done in order to find new and more diverse sensors, and to date there are several companies offering ready-to-use electronic tongue. Traditional chemical and biological sensors are highly specific for certain compounds. Large, expensive gas chromatographs, for instance, which separate organic chemicals based on molecular weight through coiled glass tubes, must be attached to at least four different detectors to identify complicated compounds.

The rapid alert system for food and feed (RASFF) provides rapid information on newly identified risks to the consumer. When an EU government spots a food or feed item which it thinks could put consumers at risk, it uses this network to spread information on the potential risk and the action it has taken to stop the item entering the food chain. This ensures that the risk is publicized throughout the EU very quickly and that authorities in other countries can take swift action if they think their own citizens are also at risk.

The purpose of a quality control program is to acquire reliable information on all the attributes of a product, which affects its quality [3]. The methods used to measure quality can be subjective, as in taste tests or they can be objective, such as physical, chemical or microscopic analysis. Subjective methods are based on the opinions of the examiners and because they require the use of our various senses, they are often called “sensory analysis”. Intelligent sensors can essentially perfect the whole control system due to increasing preciseness and a rational processing of signals received from the sensory element. An existing problem of measuring devices and sensors is the problem of a precise control of production processes. The problem of consumer’s provision with qualitative food products is the efficiency problem of any production. Therefore, it is topical to design new generation automatic devices for the risk assessing in the chain of agricultural production. One direction of the develop-ments can be the elaboration of low-cost electronic rapid risk assessment devices with “Artificial Intelligence” (AI) elements, which continue the development of microprocessor technology [6].

The compatibility of measuring processes and functions in the “compensating stage” can be taken over by the cognition subject with its intellectual apparatus. In the elaboration of intellectual measu-ring systems it has to be understood that such system can be open to man’s (expert’s, specialist’s) intellect, knowledge, practical experience (also not formalized and not systemized) and even to intuition Automatic identification at the critical control points should be achieved for all stages of food production starting with the obtaining of raw materials or the production of component parts up to their marketing. Therefore, at the start of the precise, safe, operative and objective technological process a information flow has to be established throughout all the production stages. The solution of this problem is hindered by the lack of such measuring devices [7].

The global scientific community has acknowledged research on an artificial tongue sensor. E-tongue, E-nose is a system for automatic analysis and recognition (classification) of liquids or gases, including arrays of non-specific sensors, data collectors and data analysis tools. Electronic tongues are used for liquid samples analysis, whereas electronic noses –for gases. The measuring result of E-tongue and E-nose can be the identification of the sample, an estimation of its concentration or its characteristic properties.

Artificial tongue (Fig. 1) usually consists of three functional knots: a primary sensing element (measuring transducer), processor and a registering device. Device uses electrical currents to produce recognizable patterns on a graph that are different for different compounds. The human tongue functions in a similar way because the sense of taste is no more than the recognition of electrical signal patterns for foodstuffs and other substances that have previously been encountered and remembered. Taste is learned, he added. Possibilities of the computing technique allow to process operatively great amount of information by definite algorithm. That promotes not only an optimal collection of measuring data from risk assessment sensors, but also a correction of their measuring result in accordance with the required accuracy of information for users, producers and consumers.

Fig. 1. **Artificial tongue "Logicor- AT" – intelligent device for rapid risk assessment, consumer's protection and for rapid alert system in the chain of agricultural production**

This device uses electrical currents to produce recognizable patterns on a graph, that are different for different compounds. Device uses electrical currents to produce recognizable patterns on a graph that are different for different compounds. The human tongue functions in a similar way because the sense of taste is no more than the recognition of electrical signal patterns for foodstuffs and other substances that have previously been encountered and remembered. Taste is learned, he added. Automatic identification at the critical control points should be achieved for all stages of food production starting with the obtaining of raw materials or the production of component parts up to their marketing. Therefore, at the start of the precise, safe, operative and objective technological process a information flow has to be established throughout all the production stages [1-3, 7, 8].

The measurement and evaluation of quality is a complicated affair. Most organizations employ professional technicians to carry out this task, but this has not always been the case. This new technology has many advantages. Problems associated with human senses, like individual variability, impossibility of on-line monitoring, subjectivity, adaptation, infections, harmful exposure to hazardous compounds, mental state, are no concern of it.

Methods, Materials and Results

The electronic tongue or nose system performance is dependent on the quality of functioning of its pattern recognition block. Various techniques and methods can be used separately or together to perform the recognition of the samples. After measurement procedure a preprocessing block transforms the signals. The results obtained are inputs for Principal Components Analysis, Cluster Analysis or Artificial Neural Network.

Research was focused on the development of classification algorithms. The multi-sensor system utilizes an imaging system, an impact sensor, a sensor of electro conductivity (constant and alternating current), an electronic chronometer for determination of relaxation time (T_{rel}), an ultrasonic sensor, a gauge for measuring electrical resistance (R_a), a force gauge and an "artificial tongue" measurement device. Various ANNs were trained using 155 dataset with back-propagation (BPA) and back-transformation (BTA) algorithms for $2 \cdot 10^5$ epochs. Further on "reference" functions of the influence factors are determined and feedback algorithm is synthesized in the form of ANN "self-learning" programs. For the estimation of absolute error of tested algorithms was used standard deviation function $\sigma = f(N)$.

A result of compared testing of back propagation (BPA) and back transformation (BTA) self-learning algorithms for artificial tongue "Logicor AT" on Fig. 2 and on Fig. 3 is reflected.

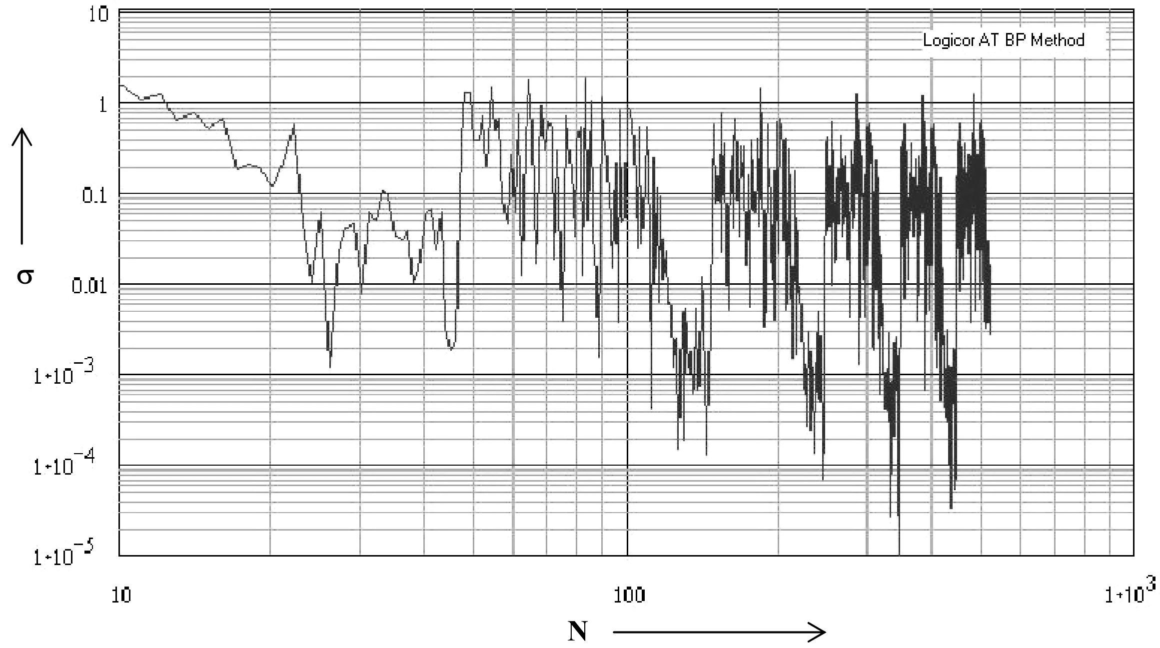

Fig. 2. **Testing the back propagation self-learning algorithm for artificial tongue "Logicor AT", $\sigma = f(N)$**

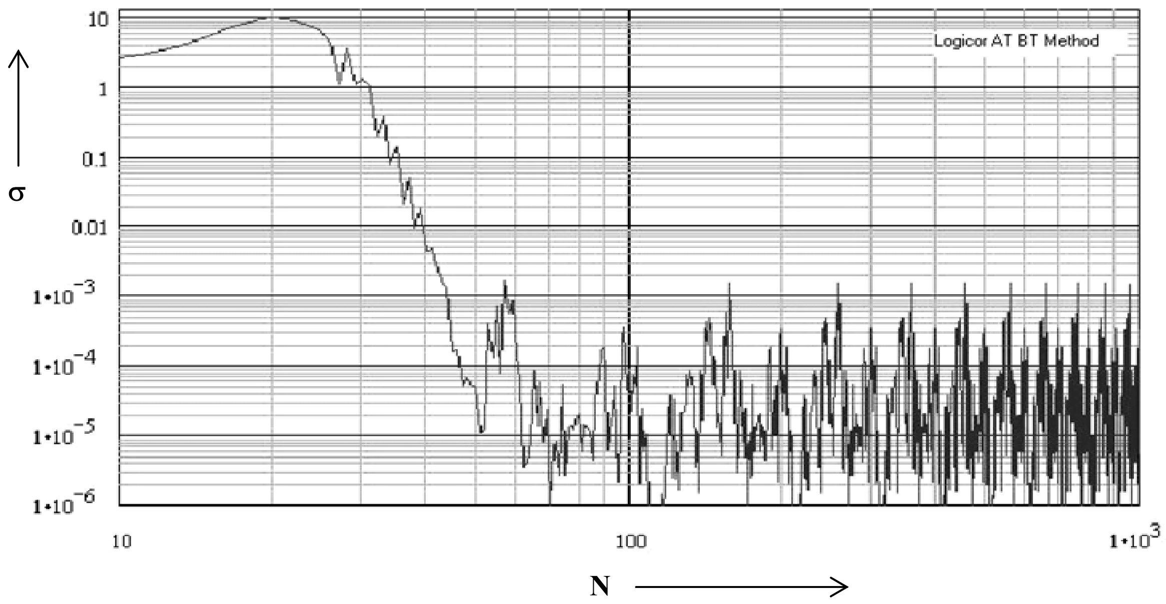

Fig. 3. **Testing the back transformation self-learning algorithm (author prof. G. Moskvin) for artificial togue "Logicor AT", $\sigma = f(N)$**

The number of hidden neurons in three layers models with sigmoid, hyperbolic tangent and secant transfer functions varied from five to 20 with increment of five. After training the ANNs, the performance of ANNs was discussed. Optimal configuration model was selected from 12 ANN configurations based on the standard deviation of mean absolute error.

"Behaviour" factor analysis of the object of interest has to be considered at the basis of the second type of bionic models. The overall quality of a fruit is not a linear combination of all measurable quality parameters. This presents major problems as to how these measurements should be combined to quality indices and grading decisions.

The quality of fruit is a combination of numerous parameters such as firmness, acidity, aroma, color, color uniformity, bruises, scars, cuts, presence of soil, size, shape or insects diseases. In the most generic sense, quality refers to the combination of characteristics that are critical in establishing a product's consumer acceptability. In food industry, this is usually an integrated measure of taste, purity, flavor, texture, color, appearance and workmanship. In a highly competitive market, another criteria of quality can be 'value' or a consumer's perception of the worth of the product based upon the funds available for the consumer. This is true for all stages of quality's traceability – from environment to home. The main parameters are specific to the individual fruit. Thus, the concept of this work is to develop a system, that can classify fruits based upon several parameters (vision, taste, firmness, smell and weight) by using multi-sensor data acquisition. The use of E-tongue involves 3 phases. The learning phase – after establishing number of neurons, layers, type of architecture, transfer function and algorithm, network is forced to provide desired outputs corresponding to a determined input. It is made by adjusting the "synapses" weights in order to minimize the difference between desired and current output [6, 7, 8]. The validation phase – verification by means of different data with similar characteristics from data, used in the learning phase. The production phase – in which the network is capable of providing outputs corresponding to any input. Despite the numerous techniques developed for non-destructive evaluation of quality, for example of fruits and vegetables, quality sorting is still primarily based on manual decisions and manual work. Preliminary experimental determination of optimal K_{ind} for the standard apple is shown in Fig. 4.

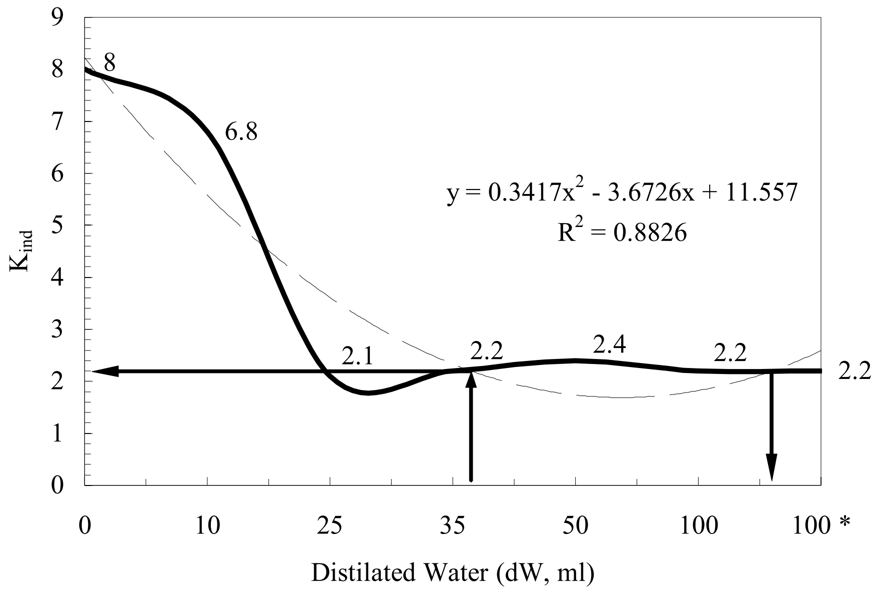

Fig. 4. **Determination of optimal K_{ind} for the standard apple with add to sample 35 ml distillated water**: $K_{ind} = f(dW)$; A_s = 1.0…5.0 dB; F_{ind} = 7.0 kHz; dW =100* after waiting 40 min

The main results of preliminary experimental research prove that quality and conformity control of agricultural products and raw materials can be determined by using the intelligent artificial tongue "Logicor-AT", Fig. 1. Techniques and criteria for training sets for the classifier were developed in such a way that only about 150 dates was needed to achieve good conformity classification resulting in 88% of correct classifications for objects that were tested at different dates. A classifier that was trained can achieve 88% accuracy in the same classification. The presence of a microcomputer in the measuring channel allows the use of special testing programs carrying out identification experiments of a measurable medium by the help of the use of definite physical effects. The peculiarities, conditions and specifics of food production require elaborate simple, safe, inexpensive and precise electronic conformity control devices. The elaboration of such devices is the decisive factor in operation of the conformity control systems for the quality of food and other products.The research on "consumer intellect" models is carried out through the synthesis of the non-traditional risk assessing method by using low- cost intelligent instruments. In general, it allows improving scientific knowledge's on the basis of informative service and quality control programs and guaranteeing legal protection of interests and rights of each consumer.

Conclusions

1. The risk assessing is the scientific precautionary process for state-of-the-art policies. When drawing up its policy on food safety and the acceptable level of risk, EU takes decisions based on sound scientific advice and the latest technological developments. The European Food Safety Authority (EFSA) set up in 2002 plays a central role in this process.
2. In agriculture are even more often applied biosensors for risk assessing and quality control of agricultural products. The biosensors industry is growing.
3. In generic sense, quality refers to the combination of product characteristics that are critical for consumer acceptance. In the food industry, this is usually an integrated measure of taste, purity, flavor, texture, color, appearance and handling. In a highly-competitive market, another criteria of quality can be 'value' or the consumer's perception of the worth of the product based upon the funds available for it.
4. The sensometric aims is: increase the awareness of the fact that the field of sensory and consumer science needs it own special methodology and statistical methods; act as the interdisciplinary institution, worldwide, to disseminate scientific knowledge on the field of sensometrics.
5. The comparative researches of self-training algorithms for a rapid risk assessing with the help of the intelligent device "artificial tongue" Logicor-AT have shown advantages for back-transformation algorithms, which was elaborated and developed in LUA for the first time in the area of intelligent technologies about 30 years ago.

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