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# ÉLELMISZERFIZIKAI KÖZLEMÉNYEK

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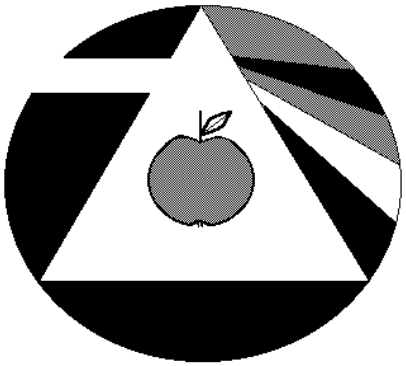

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# EDITORIAL

The JOURNAL OF FOOD PHYSICS was published first in 1988, parallel with ÉLELMISZERFIZIKAI KÖZLEMÉNYEK, written in Hungarian. In 2000 the editorial board decided to combine the English and Hungarian versions in one joint issue. So our authors have the right to publish their articles both in English and Hungarian, in case of Hungarian one with English abstract, as well.

In this volume (XIX) we publish the oral and poster presentations of the 7th International Conference of Food Physicists, organized in Senta, Serbia, 30 June-01 July, 2006. So practically this volume is a proceedings of the papers of the ISFP congress. The sequence is the same, as we had the presentations in Senta, at the ISFP meeting. No changes were carried out in the papers, got from the authors.

As You know the first ISFP (International Society of Food Physicists) meeting was organized in Budapest, 1994, followed by the Bucharest (1996, Romania), Lublin (1998, Poland), Istanbul (2000, Turkey), Brno (2002, Chech Republic), Pecs (2004, Hungary) conferences. Please, do not forget to join to the 2008 meeting in Bulgaria, Plovdiv. And in 2010 we plan to have the ISFP congress in Nitra, Slovakia.

We had a wonderful meeting in Senta, in a small, originally a Hungarian town of the Vojvodina region of Serbia. May I mention that the ISFP conference was a part of the program of the 500th anniversary of the town Senta. Thanks for the excellent organization to the meeting chairman, ing. Illes Feher.

We plan to publish in the future 1 volume per year, so the next one will be the XX. We do hope that we can continue the work – beginning in 1988 – to publish the first journal of the world, specialized on food physics, which is a subscience between applied physics and food science. Let me ask your support and effective help!

Prof. A.S. SZABO
Editor-in-chief

# THE GROWING IMPORTANCE OF ASPECTS OF FOOD SAFETY AND FOOD PHYSICS IN THE INDUSTRIAL FOOD PRODUCTION

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ABSTRACT

In the paper information is given about some special questions of aspects of food safety and application of principles of food physics in the agro-food sector. The role of food safety has been developed significantly in the last 2-3 decades. The food production and processing of quality food and safe food are of primary importance. Food production is based on the principles of GAP, GMP and GHP, and different methods and tools (e.g. HACCP, ISO-9000-2000, TQM, ISO-22000) for quality control, safety and quality assurance are in use. Today the agricultural production and the industrial food processing are focused dominantly on the quality, and one of the basic requirements in the agro-food sector is the safety.

There are different methods and techniques to produce safe food. The up-to-date food technologies and quality measurements involve the application of different physical methods – high pressure, pulsing electrical field, nondestructive techniques (e.g. NMR, NIR-NIT) for chemical composition determination, radiation techniques etc. – as well. Using ionizing and non-ionizing radiation technologies it is possible to fulfil e.g. the following expectations: decrease of the microbial contamination, increase of the storability, improve of the sensory properties.

## INTRODUCTION

The quality food never goes out of style. Today the production of quality food and safe food is of primary importance, although safe food and quality food is not the same! Quality food should be safe, but safe food can be not really quality one (e.g. not good sensory properties.) So

safety – in the whole chain, from farm to fork - is only one requirement of the quality in the food processing and consumption.

## FACTORS DETERMINING THE QUALITY OF FOOD PRODUCTS

Safety is a basic requirement, meaning no harmful effects from the food, eaten by humans. The other factors determining the quality of the food products are the following:

- sensory properties (value of pleasure)
- quantity , volume
- chemical composition
- packaging, labelling
- special (microbiological, toxicological, radiometrical) parameters

## HAZARDS FROM EATING FOOD

There are different hazards (risks) from the foodstuffs. The opinion concerning the rank of hazards in case of experts and the public is perfectly different.

To the food experts and nutritionists the rank of hazards from eating food is the following:

- microbial safety
- over-nutrition
- non-microbial safety (contaminants, natural toxins, agrochemicals, food additives)

To the public the rank of hazards from eating food is the following:

- pesticides
- new food chemicals
- chemical additives
- familiar hazards (fat and cholesterol, microbial sopoilage, junk foods)

## PRINCIPLES OF FOOD PROCESSING AND FOOD QUALITY CONTROL

Today the foood production and industrial food processing are based on principles of GAP, GMP and GHP(1)(2)(3). GAP means good agricultural practice, GMP means good manifacturing practice and GHP means good hygiene practice. In case of food processing GMP involves GHP, there is no GMP without GHP.

Quality control and quality assurance in the food sector are based on principles of HACCP, ISO-standards, TQM. HACCP (hazard analysis, critical control points) is a system for safety. ISO standards – e.g. ISO-9000/2000, ISO-22000 – and TQM (total quality management) are different tools for the quality control and safety. ISO is a static model, TQM a dynamic one.

## TECHNOLOGIES FOR PRODUCTION OF SAFE FOOD

Earlier a lot of different techniques and technologies – partly physical ones - were used to produce safe food. E.g. smoking, dehydration, chilling, freezing, ohmic processing, aseptic technique, microwave pasteurisation. Recently some new directions – e.g. microwave sterilisation, pressure sterilisation, pulsed technologies, application of electrical and magnetic fields – are in use.

The development of these new technologies and the successful application of these new techniques in the modern food processing are in close connection with the development of food physics, a subscience covering the field of food science and applied physics(4)(5)(6).

## RADIATION TECHNIQUES IN THE AGRO-FOOD SECTOR

Various radiation techniques – ionizing and non-ionizing ones – are is use in different fields of food sector, not only in the production and processing, but in quality control or food investigations, as well(7)(8). Let us mention a few ones:

- nuclear techniques, ionizing radiation technologies (e.g. gamma sources, X-ray equipments, electron accelerators)
- non-ionizing radiation methods (e.g. light-techniques, IR, UV, laser, SYNERGOLUX technique)

- radiostimulation and radiomutation in agriculture
- isotope techniques, tracer techniques
- radioanalytical techniques (e.g. activation analysis, XRF)
- nuclear measurement techniques (quantity, level, thickness etc.)
- radiometrical control of the food chain, radioecological measurements

EXPECTATIONS OF THE MODERN FOOD PRODUCTION

Such expectations are e.g. the following:

- decrease of the microbial contamination
- increase of the storability
- improvement of the sensory properties

These requirements can be fulfiled using different radiation methods. In general these techniques are environment-friendly ones and useful from economical point of wiev, as well.

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# RHEOLOGICAL MODELS OF PECTIN FILMS

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## ABSTRACT

Pectin films were measured by Stable Micro Systems® penetrometer, with relaxation method. Citrus pectins from CP Kelco® were varied in charge distribution and degree of esterification. There was some amidated pectin from PIC Co as well. A controlled hydration by polyethilenglicol (PEG) 20000 solution, with and without different salts and concentrations was taken. The hydration causes swelling. The equilibrium swelling of the films (after 24 hours hydration) was investigated. The force relaxation at constant deformation, achieved by slowly stretching till a small force and after that the deformation were stored for 30 second and force decreasing were measured. The curves were analysed by two rheological models – Maxwell model and Zener model, with a small modification. Results say that the Zener model shows better fitting on relaxation curves, and give some dependences for rheological properties on pectin types and concentrations.

## INTRODUCTION

The pectin is the most important mechanical component of the plant cell-wall, because it gives an elastic connection between the cells. The pectin is hydrated by water and salt solution. The hydration environment changes during ripening and storing. In the cell wall there are two different networks: the cellulose (with parallel fibrils) and the pectin. The pectin chains bind the cell-wall components, giving an elastic connection between them (Fig. 1) (Voragen et al, 1995).

Pectins are charged polysaccharides based on uronic acid chains. A fraction of the uronic acid residues are methyl esterified. There are some rhamnose junctions with galactose and arabinose side chains as

well. Based on the amount of esterified molecules, the pectin can be low esterified (LM; up to 50%) or high esterified (HM; higher 50%). It depends on the source and the method for extraction. The charged sections can be with random or block distribution based on the number of charges in a sequence (Guillotin, 2005).

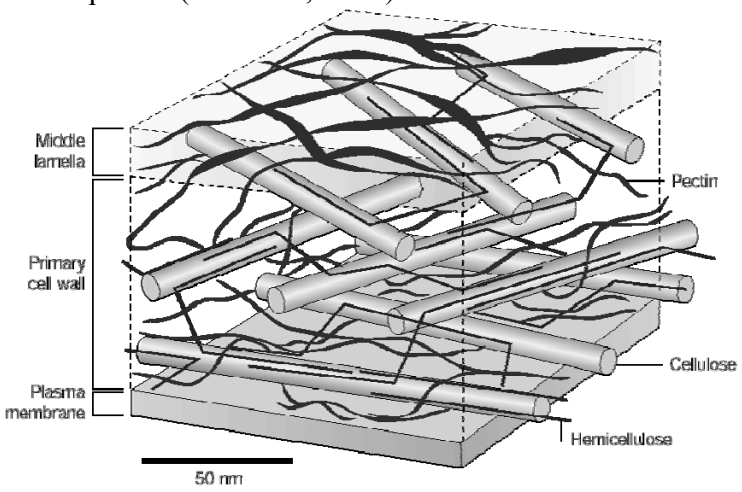



Figure 1 Microstructure of plant cell-wall

The LM pectin forms gel at low concentrations, in the presence of ions with two positive charges, for example $Mg^{2+}$ or $Ca^{2+}$. In that case the gel has egg-box structure. With more chains make dimmers, or complexes. The junction zones are 14-20 monomers (Ralet et al, 2001). The concentration of ions has high effect for the firmness of the gel, but if the concentration is too high, the result can be ion condensation (Voragen et al, 1995). Low pH or high temperature can give weaker gels. Ions, with one positive charge can't induce gelation.

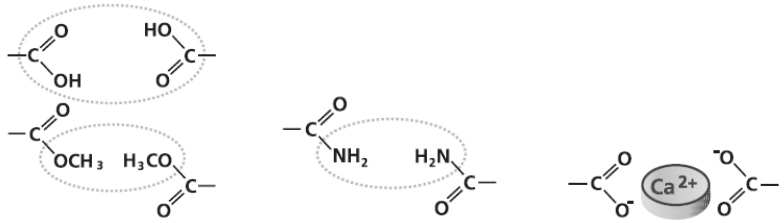



Figure 2 Gelling mechanisms

HM pectins gel, at low pH and high sugar concentration by forming of H bindings (Rolin and De Vries, 1990). Amidated pectin (Am) is deesterified by ammonia from high esterified pectin. That is low esterified, and low amidated pectin. It shows both gelling mechanism together (Fig. 2) (Guillotin, 2005).
The cross-linked and charged pectin network hydrated in equilibrium with an electrolyte solution. The equilibrium solution contains counter-ions. Excess of counter-ions generates an osmotic pressure difference between the network and the solvent. This osmotic pressure difference leads the swelling. It depends on the affinity of polymer for water, on the Donnan effect, and on the network cross-links. The swelling cause a changing of the free energy in the three dimensional polymer networks, during the hydration (Flory, 1953).

The base deformations of rheology are the elastic and viscous deformations, but the biological materials contain bound water and show these properties together. Based on the superposition principle of rheology the pectin, like other biological materials has properties of viscoelastic solid (Fig. 3) (Sitkei, 1981).

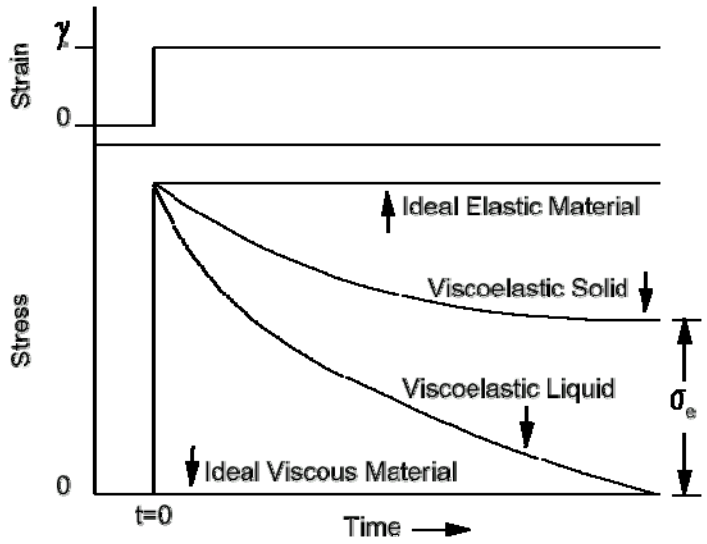



Figure 3 Material types in rheology

To study viscoelastic properties relaxation method (deformation holding in time, during extension) was used. To analyse relaxation curves two rheological models were used: Maxwell and Zener model. In the Maxwell model there is a serial connection between elastic, and viscous element. In the Zener model there is a parallel connection between elastic, and Maxwell element. (Sitkei, 1981). To follow non-exponential properties of the relaxation section the Zener model was extended with a β constant, based on literature suggestions (Dobreva et al, 1997).

## MATERIALS AND METHODS

Used pectin types showed in table 1.

Table 1 Used pectin types

| Pectin type | Method for deesterification | Esterification degree | Charge distribution |
|---|---|---|---|
| 812634-40 | Enzyme | 71.2 (HM) | Random |
| 0001-8-F | Enzyme | 36.7 (LM) | Block |
| 98246-5-A | Acidic | 70.6 (HM) | Random |
| 98246-5-E | Acidic | 35.6 (LM) | Block |
| amidated pectin LA-410 | | 29.0/20 (amid) (LM/LAm) | |

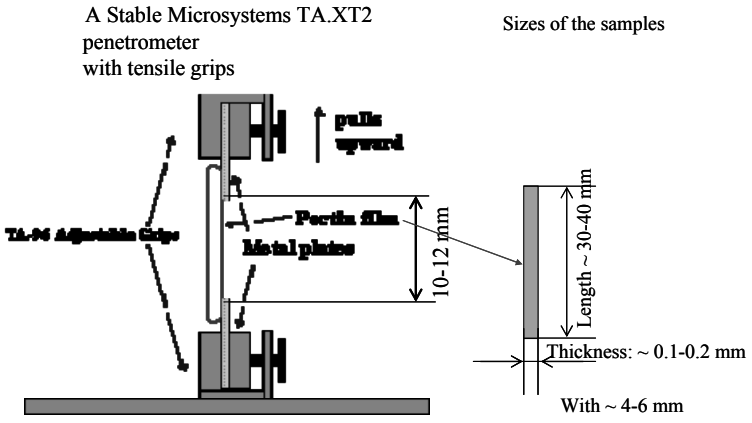
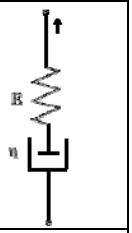
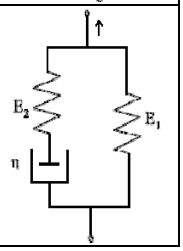
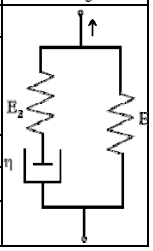



Figure 4 Instrument settings

Table 2 Equations for used models

| | Equation for loading section | |
|---|---|---|
| Maxwell model | |  |
| | $\sigma(t) = f_1 \varepsilon$ | |
| $f_1$= | Tensile (elasticity) modulus | |
| $f_0$= | | |
| $f_2$= | | |
| Zener model | |  |
| | $\sigma(t) = E_1 aT + Taf_1\left(1 - e^{-t/T}\right)$ | |
| $f_1$= | Part of elasticity modulus ($E_2$) | |
| $f_0$= | | |
| $f_2$= | $T$ | |

| | Equation for relaxation section | |
|---|---|---|
| Maxwell model | |  |
| | $\sigma(t) = f_1 e^{-t/f_2} + f_0$ | |
| $f_1$= | Slope | |
| $f_0$= | Y intercept | |
| $f_2$= | Relaxation time | |
| Zener model | |  |
| | $\sigma(t) = \sigma(t_1) e^{-t/f_2} + f_1 \varepsilon(t_1)\left(1 - e^{-t/f_2}\right)^{f_0}$ | |
| $f_1$= | Part of elasticity modulus ($E_1$) | |
| $f_0$= | Non-exponanciality (β) | |
| $f_2$= | Relaxation time | |

Pectins were varied in method for deesterification, in esterefication degree and in charge distribution. For hydration polyethylene glycol 20000 Da solutions were used. The osmotic pressure of solutions were 5 MPa, and $CaCl_2$, $MgCl_2$, KCl salts were used in different concentration (0, 10, 30, 50 mol/m$^3$) to model the ionic environment in the cell-wall.

To study rheological properties a Stablemicro-systems table penetrometer was used, in tensile mode, with deformation holding in time

while tension settings (Fig. 4). Loading forces were varied from 0.1 N till rupture point in 0.1 N steps. The loading speed was constant, 0.02 mm/s. The samples were glued to metal plates, in tensile grips. The relaxation curves were analysed by linear (Maxwell model) and non-linear (Zener model) regression (Table 2). The results from model were analyzed with mathematical way for errors, and for information contain of the constants.

## RESULTS AND DISCUSSION

1. Mathematical way for errors: table 2 shows the equations, for the regressions. From those regressions there are results for fitting errors, and parameter errors. The figure 5 compare the fittings and parameter errors. Directions 1-3 for loading section ($r^2$, fitting error parameter error), 4-8 for relaxation section ($r^2$, fitting error, errors of 3 parameters). Events for more optimal results were counted The results shows, just one parameter error was more often higher for the Zener model, like for Maxwell model. That parameter error is coming from viscoelastic properties of pectin (Fig. 5).

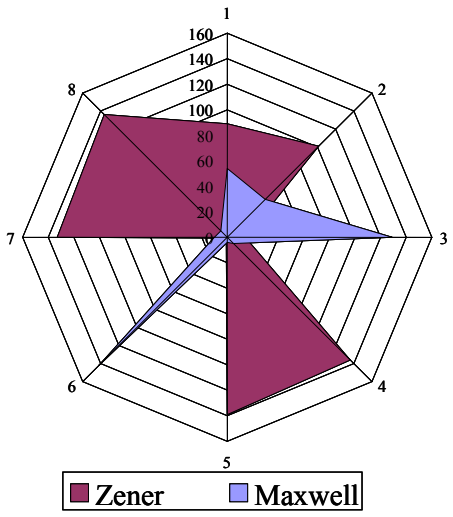



Figure 5 Error comparison
bigger area means better fitting, and smaller errors

2. Results from the model: For elasticity of pectin Maxwell model shows just the tensile modulus, like linear slope of the loading section. There is no connection between loading and relaxation section by parameters. But with Zener model for fitting curve to loading section has to use $E_1$ parameter and the relaxation time from relaxation section. Those give non-linear character for loading section, and β non-exponentiality for relaxation section. The tensile modulus shows just the differences among pectin types, like LM, HM, and Am (Kroon-Battenburg et al, 1986). Elasticity modules from Zener model ($E_1$, $E_2$) even show the effect of ion-condensation (Yoo SH et al, 2003) for $K^+$ and network collapse (Peleg, 1997) for $Ca^{2+}$, and $Mg^{2+}$ with bigger ion concentrations. Non-exponentiality shows different constant values for pectin types.

## CONCLUSIONS

- The Zener model had better fitting for the relaxation curves than the Maxwell model.
- The Zener model gave more parameters for elasticity.
- These parameters are more informative like from the Maxwell model.

## ACKNOWLEDGEMENT

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# STUDY OF PROCESSES AND PROPERTIES OF FOOD MATERIALS DURING THERMAL TREATMENT

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## ABSTRACT

The paper deals with the physical properties of food materials and with study of physical processes running in these materials during the thermal food processing technology. Characterization of food materials is presented, processes running in the materials and possible methods of study are introduced.

## INTRODUCTION

Food materials are very complicated biological materials – they have complex chemical composition (proteins, lipids, saccharines, additive components), structure, phase (food or their components are dispersed systems), conformation, etc. Properties of food materials depend in general on properties of raw materials (agricultural products) and on processing technology (Blahovec, 1993). In generally food materials, namely the grains or seeds of a certain botanic variety is in the macroscopic as well as in the microscopic scale considerably inhomogeneous, capillary-porous and wet dispersed medium. It is well known that the influence of water - existence of free or bound form, difference in binding energy of each water bond (chemical, physicochemical and physical) and sorption properties of the materials dominates among other factors at properties of food materials. The temperature is also an important factor; it is the value which influences nearly each property of the material.

Moisture content and temperature are the most important physical properties that influence physical and physiological processes running in

the food materials, for that reason they are some of the main controlling factors used in food processing. Typical thermal food processes - drying, cooling, freezing, boiling, baking, pasteurisation and sterilisation induce some physical and chemical processes in the material such as heat and mass transport, vaporisation, melting, freezing, crystallisation, crystal modification, denaturation, chemical reaction, etc.

Study of physical processes – transport processes and phase transitions – running in the material during thermal treatment requires knowledge of thermophysical properties of material.

Heat and mass transport are processes with direct impact on the food quality. The problem of transport phenomena covers very wide area of physical phenomena connected with the mass and the energy transport and has been elaborated in different kinds of materials (Ingham – Pop, 1998). Biological materials are complicated to describe from the point of view of the transport mechanism. Transport processes are influenced by properties of the material – transport properties. Contribution to the study of the heat transport in the food materials, to the measurement of thermophysical properties and to the study of factors affecting the heat transport in the food material can be found in (Vozárová, 2002, Vozárová, 2005).

Physical and chemical processes running in the material due to temperature changes can be investigated by method of thermal analysis. They are the analytical techniques that measure physical and chemical properties of the sample as a function of the temperature or time (Haines, 1995). The sample is subjected the temperature program and the dependence measured value (heat, mass, volume, specific heat etc.) on the time and temperature are determined. It is provided by using following methods of thermal analyses:

- differential thermal analysis (DTA), differential scanning calorimetry (DSC) – provides information on thermal effects which are characterized by an enthalpy change and by temperature range, such as phase transitions (melting, crystallization etc.)
- thermogravimetric analysis (TGA) – measures the mass (change of the mass), provides information on the content of components.

Interpretation of the obtained TGA, DSC curves provides information about processes running in the materials, changes of physical and

chemical properties and conditions of it. The methods of thermal analyses and experimental apparatuses are described in details in (Haines, 1995).

## MATERIAL AND METHODS

Measurements of physical properties – specific heat, thermal conductivity and mass as a function of the temperature were realised. Experimental methods of thermal analysis – differential scanning calorimetry, thermogravimetry and hot-wire method were used for an estimation of thermal behaviour of granular materials. Measurements were performed on the samples of colza *Brassica napus,* mixture of cultivars. Bulk density, moisture content and date of sampling are in the table 1.

Table 1 Characterization of samples

| **Sample** | **Moisture content, w.b.** (%, $kg.kg^{-1}$) | **Bulk density** ($kg.m^{-3}$) | **Date of sampling Locality** |
|---|---|---|---|
| **Colza**, mixture, sample 1 | 6,75 | 631 | 07-17-2003 Hontianske Nemce |
| **Colza**, mixture, sample 2 | 7,78 | 635 | 09-12-2003 Hontianske Nemce |

Differential scanning calorimeter DSC $822^e$ (METTLER TOLEDO) was used for measurement of the specific heat of colza as a function of the temperature. Measurements were performed on the sample of colza (sample 2) under nitrogen atmosphere (flow rate 80 ml per minute) in the temperature range from 0 °C to 40 °C with heating rate 5 K per minute. The sample of colza was measured as a whole. Weight of the samples is 3 – 4 mg. The samples were embedded in standard aluminium pans where an empty pan was used as a reference.

Thermogravimetric analysis were performed on the sample of colza (sample 2) on the air (flow rate 80 ml per minute) in the temperature range from 25 °C to 500 °C with heating rate 5 K per minute. Measuring equipment is TGA/SDTA 851$^e$ (METTLER TOLEDO).

The hot-wire method and the home made computer-controlled experimental apparatus, which allows the determination of the thermal conductivity of solid, powders and granular materials was used (Dawis, 1984, Vozár, 1996). Measurements of the thermal conductivity as a function of the temperature were performed on the air at the atmospheric pressure in the temperature range from room temperature up to 100 °C or 140 °C respectively on the samples of colza (both samples) with volume 1 $dm^3$. Measurements for the given sample were repeated 15 times with the temperature stabilisation (2 hours) meanwhile due to achievement the needed accuracy. The moisture content of the samples was determined by electronic (conduction) moisture meter HE 50 (PFEUFFER).

## RESULTS AND DISCUSSION

Fig. 1 presents DSC curve of colza (sample 1) obtained in the temperature range from 0 °C to 40 °C. Specific heat of the sample at the temperature above 0 °C linearly increases up to the temperature 40 °C. Values of the specific heat of materials are significantly influenced by presence of the water. Specific heat of the air, proteins and saccharides are low, between 1,1 - 1,2 $kJ.kg^{-1}.K^{-1}$. Fats have almost double value of the specific heat in the comparison with proteins and saccharides (Blahovec, 1993), which influenced obtained values of colza.

Fig. 2 presents the thermal conductivity as a function of the temperature. Thermal conductivity of the granular food materials (grains and seeds) is influenced by the chemical composition of the material, by the moisture content and by the presence of the air between individual elements. Thermal conductivity of saccharides and fats is between 0,05 – 0,2 $W.m^{-1}.K^{-1}$, thermal conductivity of proteins are lower, values are between 0,02 – 0,05 $W.m^{-1}.K^{-1}$ (Blahovec, 1993). Presence of the water in the sample of colza slightly affects the temperature dependency of the thermal conductivity due to low moisture content of the both samples. Changes of the progress of the thermal conductivity of colza as a function of temperature in the temperature about 70 °C can be caused not only by

releasing of the water or other unstable ingredients (oil), but by phase transition of the starch as well.

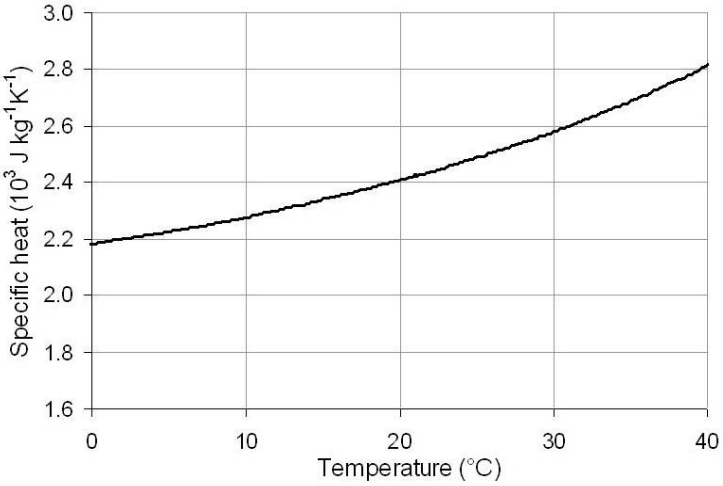


Fig. 1 Specific heat at the constant pressure of the colza (sample 2) as a function of the temperature

Fig. 3 presents TGA curve of the sample of colza (sample 2). Slow decreasing of the sample mass above temperature 100 °C is caused by releasing of the water and other unstable ingredients of seeds (oil). Stronger decrease of the sample mass between 350 °C and the 400 °C is caused by combustion.

## CONCLUSION

The paper presents results of the measurement of the specific heat at the constant pressure, thermal conductivity and mass of colza as a function of the temperature. It is shown that the temperature is one of essential factors that influence processes and properties of the food materials during thermal treatment. Monitoring of the thermal behaviour of materials provides the important information for the analyses of the optimal food processing regime proposal.

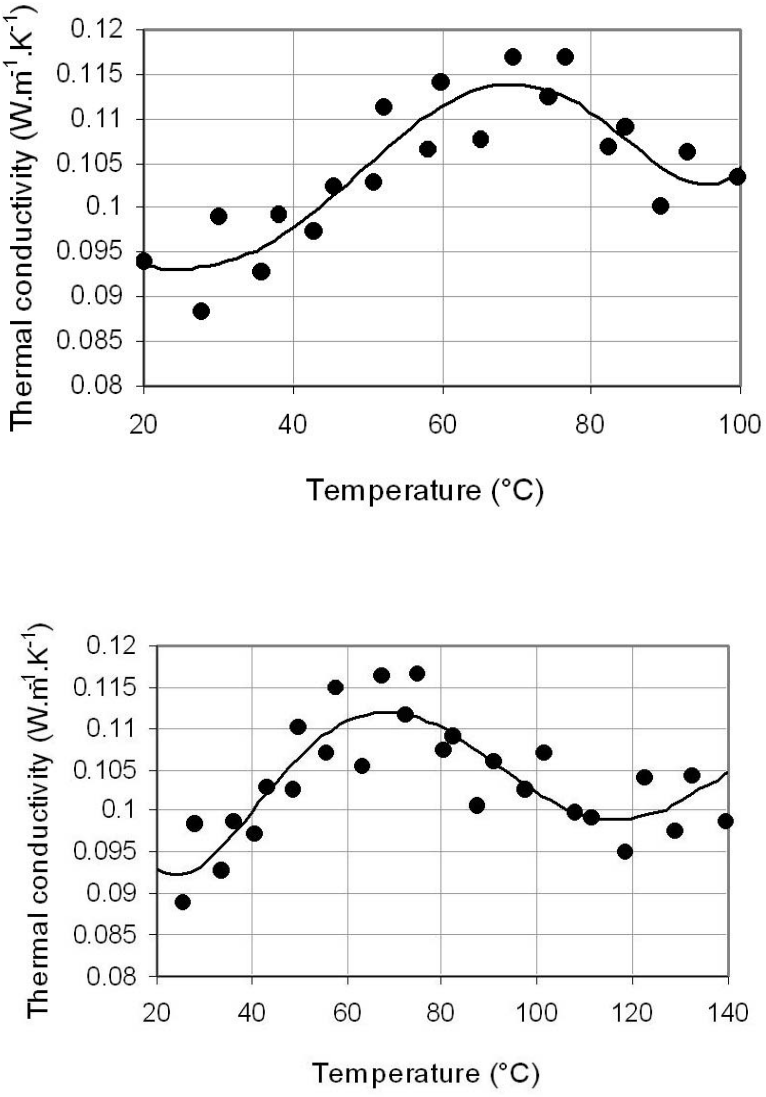


Fig. 2 Thermal conductivity of colza (sample 1-on the left, sample 2-on the right) as a function of the temperature

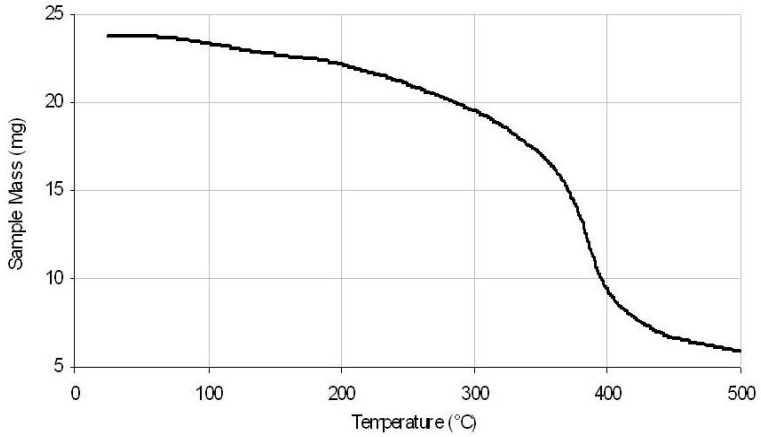


Fig. 3 TGA curve of the colza (sample 2)

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# IDENTIFICATION AND CHARACTERIZATION OF DOMESTIC WHEAT VARIETIES BY HPLC AND HPCE

HIGH-PERFORMANCE LIQUID CHROMATHOGRAPHY
AND
HIGH PERFORMANCE CAPILLARY ELECTROPHORESIS

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## INTRODUCTION

The wheat production, processing, market and other end-users have begun to demand fast and reproducible methods and techniques for varietal identification. High performance liquid chromatography method (HPLC) is widely used for wheat varietal identification and of the other cereals (1, 2, 3), as well as for their characterization trough the gluten proteins (4). This method was used for varietal identification of domestic wheats in combination with the method of acid polyacrylamide gel-elecytrophoresis (A-PAGE) and in wheat quality studies (5, 6), and also in heredity study of gliadin proteins in the early wheat breeding stage (7).

Another technique, which is the simplest and the most often used for the separation of the wheat proteins and for varietal identification, is the free zone capillary electrophoresis (FZCE), which is relatively new technique in the field of cereal hemistry and technology. This technique enables a fast separation of gluten proteins with high resolution (8),

differentiation among the wheat cultivars (9), and their qualitative and quantitative analyses (3).

The aim of this study was to identify wheat cultivars of domestic origin (*Triticum aestivum, L.*), and to characterize the gliadin proteins, using the method of reversed-phase high-performance liquid chromathography (RP-HPLC) and the method of free zone capillary electrophoresis (FZCE).

## MATERIALS AND METHOD

Bread wheat cultivars (*Triticum aestivum, L.*) grown in Skopje region, the breeding lines of the Institute of Agriculture in Skopje, were analysed in this study.

RP-HPLC analyses: The method of Lookhart et al (3) was applyed. Gliadins were extracted from 100 mg sample from the well ground wheat kernels, with 50% propanol-1. First albumins and globulins were removed, and also extraction only with propanol was done. In the HPLC system 5-10 µl sample were injected. Analyses were performed at $70^0$ at the flow rate of 1 ml/min with multistep gradient system for 26 min. Solution A was 0.1% TFA in water, and solution B was 0.1% TFA in ACN. Detection was performed at 200 nm in the UV region.

FZCE analyses: The gliadins were extracted with 50% propanol-1after removing albumins and globulins, according to the method of Bean and Lookhart (9). Extraction procedure, aparatous description (Beckman PACE 5510/2100), preparation of capillaries and the method used (FZCE) are according to Bean and Lookhart (10). The rejection time of samples was 1 s at pressure of 1.5 psi. All separations were performed at 30 KV and 45 $^0$C using uncoated silica capillaries (20 cm Ld) x 50 µl inner diameter. Buffer separation was 50 mM iminodiacetic acid (IDA) containing 20% acetonitrile (ACN) and 0.05% hydroxypropyl-methyl-cellulose (HPMC).

RESULTS AND DISCUSSION

By the method of RP-HPLC the gliadin proteins were separated on the basis of the surface hydofobicity and they were characterized by the elution time and the high of the separated picks. Analyses made by this method are shown on the Fig.1. The separation time for gliadin proteins was 22 min and the number of the eluted peaks was up to 25.

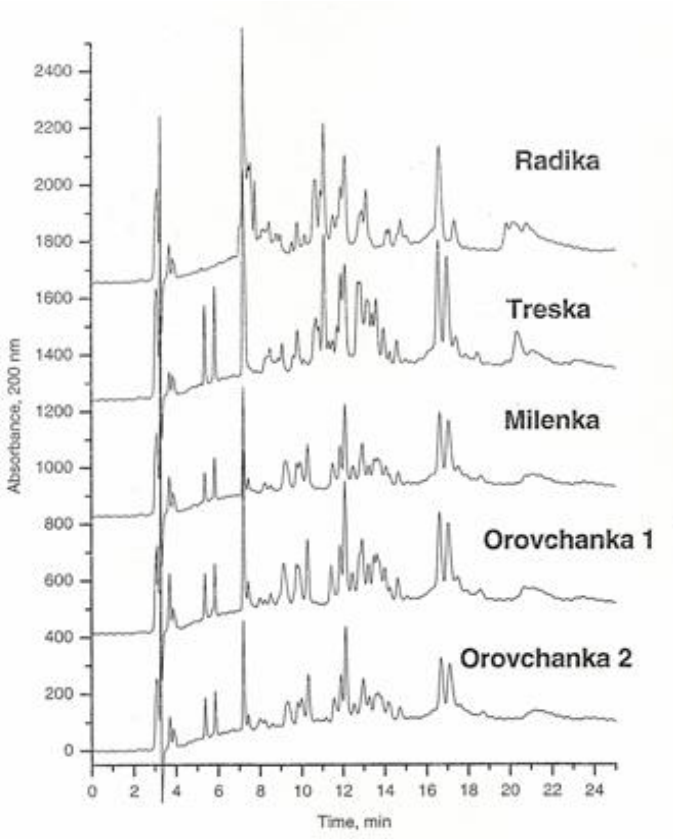


Fig.1 Gliadin extracts of Macedonian bread wheat varieties analysed by RP- HPLC method

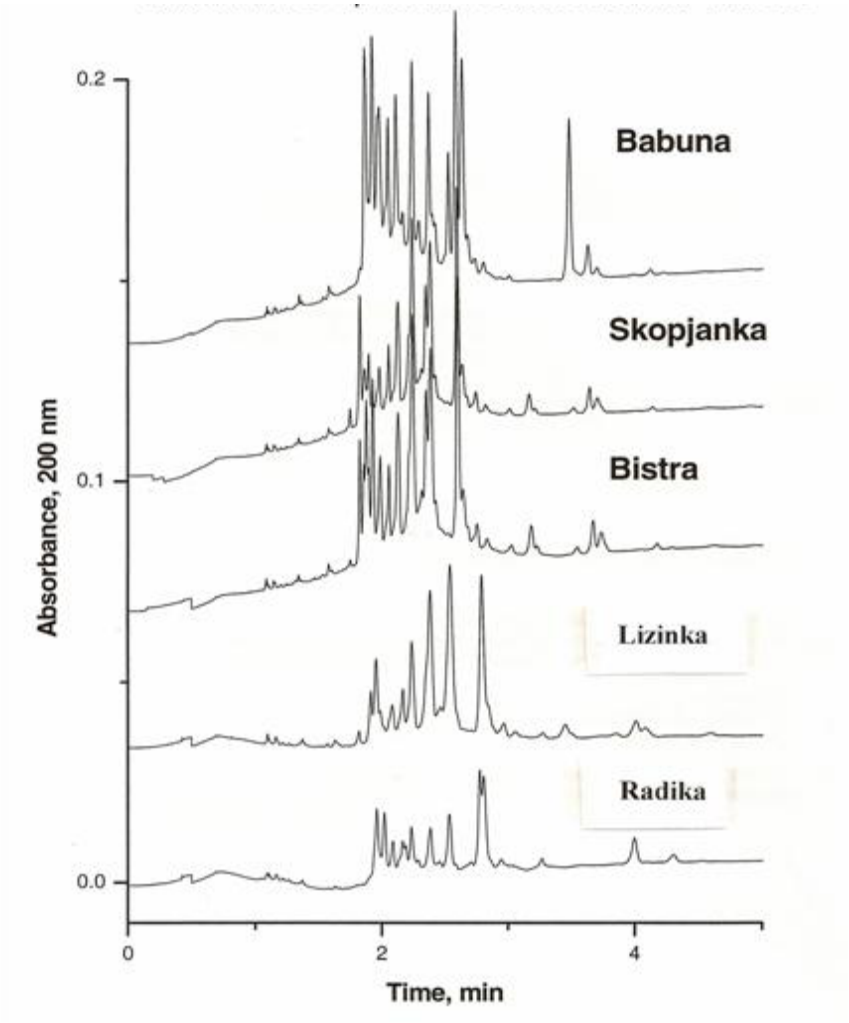


Fig.2 Gliadin extracts of Macedonian bread wheat varieties analysed by HPCE method

With FZCE technique high resolution and reproducibility of gliadin electroforegrams were obtained, which was shown on the Fig. 2. During the four minutes only, gliadins were separated in many peacks (up to 17), comparing to the HPLC method (Fig.1). The wheat varieties which

were analysed by the both identification methods differed within a class, showing similarities and differences in their gliadin composition.

## CONCLUSIONS

As conclusion can be stated that by HPLC and FZCE methods identification of domestic wheat varieties and characterization of gluten proteins has been performed, giving *"the finger print"* of the varieties. It was demonstrated their suitability as a fast, equrate and reproducible technique for analysis of gliadin proteins enabling the wheat variety differentiation within a class. This is very important for the production of new wheat varieties, in the early generation of breeding composition of gliadin proteins to be determined and quality properties to be predicted, which will enable breeding of wheat genotypes with desired quality properties. This also enable the applied methods to be included as new standards for wheat quality determination at the wheat market.

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# DETERMINATION OF FOOD RADIOACTIVITY BY MEANS OF LOW-LEVEL GAMMA SPECTROSCOPY

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ABSTRACT

The recognition of radionuclides from characteristic gamma rays is the most widely used method for activity concentration determination. It is shown that by means of high resolution low background gamma spectroscopy most of radionuclides in the food can be determined. By means of passive and active shielding of the detectors detection limits far below 1 Bq/kg can be achieved. Some recent results on radionuclide content of food on the market will be present. The role of TENORM sources in food contamination will be discussed.

## INTRODUCTION

Nowadays, both natural and produced radionuclides are present in the environment. In the soil and water the content of natural radionuclides is enhanced by non-nuclear technologies (coal combustion, mining, fertilizing, etc.) while the artificial radionuclides have entered the environment due to atomic bomb explosions and nuclear arm testing. The most significant present-day produced radionuclide is $^{137}$Cs of Chernobyl origin. Radionuclides from the environment are transferred to foods and human body through complex nutrition chains (ICRP, 1975; UNSCEAR, 1982; Linsley, 1997).

To assess the internal dose of radionuclides taken in by food, the activity of each radionuclide in food and water has to be measured. Since all radionuclides except $^{90}$Sr and $^{3}$H, emit gamma rays, gamma-spectroscopy is accepted as the most suitable method for simultaneous

multi-isotopic analysis. The ingestion dose can be estimated from the activity concentration of each radionuclide in food, taking into account the amount of the ingested food and using appropriate models (ICRP, 1991).

The Laboratory of Nuclear Physics at the Faculty of Sciences in Novi Sad has been monitoring radioactivity in food for years. The program covered both natural and artificial radionuclides in the environment and the ambient gamma-dose rate level. To the monitoring program, the Laboratory introduced new methods of sample preparation and new systems to detect and determine low levels of natural and artificial radionuclides in environmental samples.

## MATERIAL AND METHOD

Samples of foodstuffs were collected on Novi Sad markets in 2002. The average mass of the samples was about 0.5 kg. After the homogenization and drying at 105$^{o}$C to a constant mass the samples were put in special cylindrical vessels. The radionuclide content of the samples was measured by means of a reversed electrode "GMX" type HPGe spectrometer (ORTEC, nominal efficiency 36%, resolution 1.9 keV). The detector had a thin dead layer on its outer surface and a beryllium entrance window enabling it to detect gamma radiation below 100 keV with efficiency of about 1% for bulk sources in contact geometry. The detector is inside the 25 cm thick iron shield made of pre-Second World War cast. The detector was calibrated in cylindrical geometry by the reference standard material NBS 4350B. The average counting interval was about 50 ks. A modified version of the SAMPO program was used to process the spectra presenting spectral intensities or detection limits for 20 selected nuclides. The measuring uncertainties were quoted at 95% confidence level.

Animals and indirectly human population can be exposed to radioactivity by ingestion of plant origin forage. Today Lucerne is considered to be the most important fodder crop in the world because it is an excellent source of iron, calcium and beta-carotene. In this paper radiation levels of radium and cesium in Lucerne samples determined by gamma-spectrometry measurements in actively shielded Ge detector will be presented. The samples of Lucerne were taken from twelve different locations in Vojvodina during the summer period July – September 2004.

Raw Lucerne trees were cut on the height of 4 – 5 cm under the ground in the amount of 2 – 3 kg. The samples were then dried on the air and after that ground, powdered and mineralized by method of dry burning on the temperature of 450ºC ± 10ºC (IAEA, 1989). In the air dried samples the wet content was determined on the temperature of 105º. Gamma spectrometry measurements of the Lucerne ash were performed by means of ultra low-level background germanium detector using both active and passive shielding. Time of measurements was 80 ks. Extended range (10 keV-3 MeV) GMX type HPGe detector, nominal efficiency of 32% in 12cm thick cylindrical lead shield, lined with 3.5 mm Sn + 0.5 mm Cu is surrounded by five 5cmx50cmx50cm plastic veto shields. Veto plastic scintillators and Ge detector operate in anticoincidence mode and on that way all events that are simultaneously detected in any veto and Ge detector will be rejected. The active shield reduces the integral background by factor 3 in the energy range from 50 to 2800 keV (Bikit, 2006).

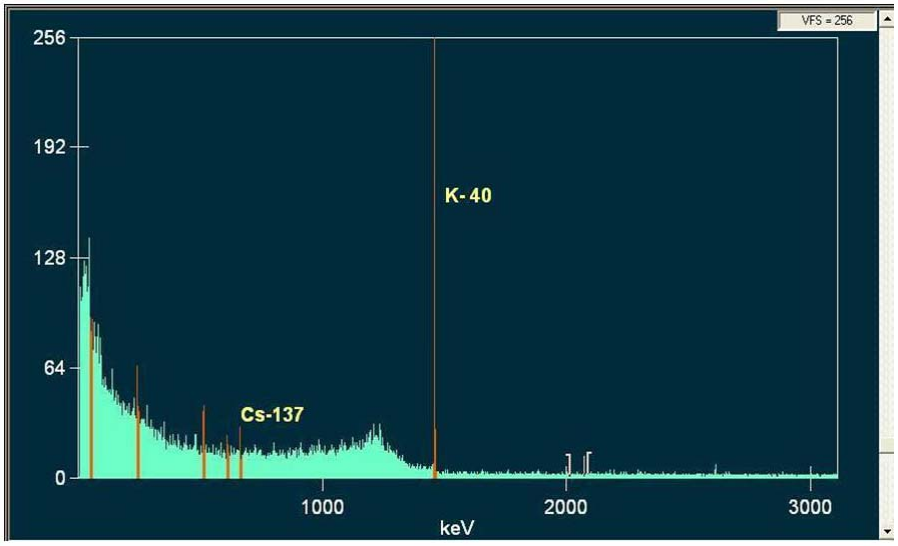


Figure.1. Gamma spectrum of Lucerne sample
measured by active shielded HPGe detector

The example of gamma spectrum of lucerne sample is shown in Fig 1. The background is significantly suppressed by the developed active

shielding method devices. For cesium $^{137}Cs$ 10 mBq/kg order of magnitude detection limits were achieved.

## RESULTS

Samples of vegetables (13), cereals, wheat and cereal products (10), baby food (12), dairy products (9), meat products (9), tea and herbs (6), meat (10), fruit (9), and cacao powder sugar and salt (4) were measured. The average activity concentrations of the radionuclides in the investigated food samples are presented in Table 1. $^{40}K$ was the only radionuclide detected in all the samples. Therefore, the ingestion dose was estimated only for this isotope (Table 2).

Results of gamma spectrometry analysis of Lucerne samples are shown in Table 3. Activity concentrations of radionuclides: $^{134}Cs$, $^{137}Cs$, $^{226}Ra$, $^{232}Th$ and $^{40}K$ were expressed in units of mBq/kg. In some of samples cesium $^{137}Cs$ were detected in traces. These concentrations are 200 times lower as compared with the results in 1988, two years after Chernobyl accident (Bikit, 1990) when the average $^{137}Cs$ activity concentration was (9.0±1.0) Bq/kg.

## DISCUSSION

The estimated annual ingestion dose (Butezatu et al, 2002) for the adult population is 194 μSv/yr, while that for infants is 61 μSv/yr. The estimated dose values based on the $^{40}K$ activity concentration did not exceed the lower limit. Generally, the estimated values are in two orders of magnitude less than the authorized annual dose limit of 1 mSv/yr absorbed from all radiation sources. The consummation of dairy products seemed mostly contribute to the estimated dose.

In conclusion, the results of gamma-spectroscopic measurements of 86 foodstuffs confirm that the radioactivity of food from the Novi Sad markets is very low. While after the Chernobyl accident in 1986, $^{137}Cs$ was the dominant radionuclide in the environment (Dragović and Stanković, 2001), it is now detected only in some samples of activities far below the limits prescribed by the Yugoslav Regulation (YR, 1999.).

Table 1/a. The average activity concentrations in food on Novi Sad markets: $A_S$ [Bq/kg]

| | Vegetables | Cereals, wheat and cereal products | Baby food | Dairy products |
|---|---|---|---|---|
| Radionuclide | $A_S$ [Bq/kg] | | | |
| $^{75}$Se | <0.04 | <0.1 | <0.1 | <0.08 |
| $^{144}$Ce | <0.3 | <0.6 | <1.0 | <0.5 |
| $^{141}$Ce | <0.1 | <0.2 | <0.3 | <0.15 |
| $^{125}$Sb | <0.11 | <0.2 | <0.3 | <0.24 |
| $^{7}$Be | 1.3±0.5 | <0.8 | <1.0 | <0.7 |
| $^{103}$Ru | <0.04 | <0.1 | <0.1 | <0.08 |
| $^{134}$Cs | <0.05 | <0.1 | <0.1 | <0.09 |
| $^{124}$Sb | <0.04 | <0.1 | <0.1 | <0.08 |
| $^{106}$Ru | <0.5 | <1.0 | <1.0 | <0.9 |
| $^{110m}$Ag | <0.03 | <0.05 | <0.1 | <0.06 |
| $^{137}$Cs | 0.14±0.07 (1) | <0.1 | 0.6±0.3 (2) | <0.14 |
| $^{95}$Zr | <0.05 | <0.1 | <0.2 | <0.11 |
| $^{95}$Nb | <0.04 | <0.08 | <0.1 | <0.10 |
| $^{58}$Co | <0.05 | <0.1 | <0.1 | <0.09 |
| $^{160}$Tb | <0.11 | <0.2 | <0.4 | <0.27 |
| $^{60}$Co | <0.04 | <0.08 | <0.2 | <0.07 |
| $^{238}$U | <1.4 | <2 | <4 | <2 |
| $^{226}$Ra | 2.4±0.4 (2) | <0.4 | <0.5 | <0.5 |
| $^{232}$Th | 0.14±0.11 (1) | 0.75±0.4 (2) | 1.0±0.5 (4) | <0.24 |
| 40K | 138±3 | 68±6 | 178±6 | 96±4 |

However, marked amounts of $^{137}$Cs were still present in some tea and herbs samples. Natural $^{226}$Ra and $^{232}$Th were found only in a few samples and even in these close to the detection limits. Supraliminal amounts of the natural cosmogenic radionuclide $^{7}$Be were present in some samples of tea and herbs, while those of $^{40}$K were as expected, present in all foodstuffs.

Nevertheless, the vicinity of several nuclear reactors and the possibility to import foodstuffs of considerable radioactivity justify the necessity of regular and systematic radiological monitoring of foodstuff markets.

Table 1/b. The average activity concentrations in food on Novi Sad markets: $A_S$ [Bq/kg]

| | Meat products | Tea and herbs | Meat | Fruit | Cacao powder, sugar, salt |
|---|---|---|---|---|---|
| Radio-nuclide | $A_S$ [Bq/kg] | | | | |
| $^{75}$Se | <0.07 | <0.31 | <0.06 | <0.04 | <0.11 |
| $^{144}$Ce | <0.5 | <2 | <0.4 | <0.4 | <2 |
| $^{141}$Ce | <0.16 | <0.6 | <0.11 | <0.7 | <0.16 |
| $^{125}$Sb | <0.23 | <0.8 | <0.17 | <0.12 | <0.3 |
| $^{7}$Be | <0.8 | 16±4 (3) | <0.6 | 1.3±0.4 (1) | <1.1 |
| $^{103}$Ru | <0.08 | <0.3 | <0.07 | <0.04 | <0.14 |
| $^{134}$Cs | <0.09 | 0.8±0.4 (1) | <0.07 | <0.05 | <0.1 |
| $^{124}$Sb | <0.16 | <0.4 | <0.08 | <0.05 | <0.09 |
| $^{106}$Ru | <0.7 | <3 | <0.8 | <0.6 | <1.0 |
| $^{110m}$Ag | <0.06 | <0.26 | <0.06 | <0.04 | <0.08 |
| $^{137}$Cs | <0.14 | 26±3 (2) | 0.41±0.27 (1) | 0.1±0.06 (1) | 1.0±0.6 (1) |
| $^{95}$Zr | <0.12 | <0.6 | <0.11 | <0.08 | <0.19 |
| $^{95}$Nb | <0.10 | <0.4 | <0.08 | <0.06 | <0.11 |
| $^{58}$Co | <0.11 | <0.3 | <0.08 | <0.06 | <0.14 |
| $^{160}$Tb | <0.25 | <0.11 | <0.22 | <0.15 | <0.4 |
| $^{60}$Co | <0.06 | <0.3 | <0.08 | <0.07 | <0.12 |
| $^{238}$U | <2 | <13 | <2 | <1.7 | <3 |
| $^{226}$Ra | <0.5 | 1.6±1.2 (1) | <0.25 | 1.9±0.4 (2) | 2.7±0.5 (2) |
| $^{232}$Th | <0.24 | 2.0±0.7 (2) | <14 | <0.2 | 1.5±0.5 (3) |
| 40K | 79±3 | 591±12 | 98±3 | 55±2 | 432±13 |

In parenthesis: number of samples in which the radionuclides were detected. < Less than the value of the detection limit given after the symbol.

The sophisticated sample preparation and counting techniques enabled the detection of $^{226}$Ra and $^{232}$Th in almost all samples. The dominant $^{40}$K activity concentration is expected for plants.

Table 2. Average activity concentrations of $^{40}K$ and estimated ingestion dose of $^{40}K$

| | Average activity concentration $A_{av}$[Bq/kg] | Estimated ingestion dose D [μSv/yr] |
|---|---|---|
| Vegetables | 138 | 43 |
| Cereal, wheat and cereal products | 68 | 38 |
| Dairy products | 96 | 53 |
| Meat products | 79 | 6 |
| Herbs and tea | 591 | 2 |
| Meat | 98 | 9 |
| Fruits | 55 | 8 |
| Cacao powder, sugar, salt | 432 | 35 |
| Total | | 194 |
| Baby food | 178 | 61 |

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Table 3. Activity concentrations of $^{134}Cs$, $^{137}Cs$, $^{226}Ra$, $^{232}Th$ and $^{40}K$ in Lucerne samples taken from different locations in Vojvodina during 2004

| Location | Vršac | S.Crnja | B.Topola | Šid |
|---|---|---|---|---|
| Isotope | A [mBq/kg fresh mass] | | | |
| $^{134}Cs$ | <75 | <100 | <80 | <75 |
| $^{137}Cs$ | 122±22 | <100 | 70±15 | <100 |
| $^{226}Ra$ | 175±100 | 302±70 | <300 | <150 |
| $^{232}Th$ | 90±62 | 218±25 | 80±15 | <38 |
| $^{40}K$ | (121±4) x$10^3$ | (140±4)x $10^3$ | (92±3)x1 $0^3$ | (103±3)x $10^3$ |

| Location | Sr.Mitrovica | Temerin | Kula | Sombor |
|---|---|---|---|---|
| Isotope | A [mBq/kg fresh mass] | | | |
| $^{134}Cs$ | <100 | <100 | <75 | <75 |
| $^{137}Cs$ | <100 | <125 | <75 | <100 |
| $^{226}Ra$ | <1500 | 275±225 | 450±150 | 175±150 |
| $^{232}Th$ | 112±28 | 132±30 | 335±22 | 65±20 |
| $^{40}K$ | (141±4)x1 $0^3$ | (191±6)x $10^3$ | (88±3)x $10^3$ | (144±5)x $10^3$ |

Table 3 continued

| Location | Sanad | Klek | S.Pazova | S.Moravica |
|---|---|---|---|---|
| Isotope | A [mBq/kg fresh mass] | | | |
| $^{134}$Cs | <125 | <68 | <125 | <1125 |
| $^{137}$Cs | <150 | <75 | <150 | 125±32 |
| $^{226}$Ra | 198±53 | 200±150 | <375 | <350 |
| $^{232}$Th | 125±75 | 75±58 | 188±55 | 105±38 |
| $^{40}$K | (272±8)x10$^3$ | (133±4)x10$^3$ | (158±7)x10$^3$ | (115±6)x10$^3$ |

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# CHANGES IN RELATIVE PERMITTIVITY AND CHEMICAL COMPOSITION OF SOME GRAINS AND SEEDS DURING STORAGE

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The measurements were done on the wheat grains mixture removed from the purchase corporation in Rybany and oil seeds from Hontianske Nemce during storage. Moisture content was determined according to standards. Electrical properties were measured at various frequencies after various time of storage in silo. The capacitance and relative permittivity decrease with frequency powerly. Results showed that specific changes occurred in quality of all wheat grains components – proteinic profile and saccharide complex. Relative permittivity decreases with storage time according to quadratic function. Similarly for the crude protein and starch content and that is why a correlation exists between changes in relative permittivity and in crude protein and starch content during storage. A correlation between the changes in relative permittivity and wet gluten content and crude fibrous material respectively do not exist. It was impossible to create the time dependencies for oil-seeds because of short storage time.

## INTRODUCTION

The temperature and moisture content have important role at the selection of suitable regime of the storage. These are the most important parameters that influence physical and physiological processes which run in the stored plant products. The temperature and moisture content affect quality of stored material and economy of storage.
Biological materials have limited durability in general. Their vegetability depends on the properties of surrounding environs and on the conditions

of the storage. Majority of the agricultural products are in the unstable or metastable states. Decrease of the stability during ageing is caused by these processes: sedimentation in biological liquids, mechanical deterioration, influence of water, temperature and radiation, transport of heat and humidity, metabolic processes, respiration, destructive processes caused by micro-organism and so on (Blahovec, 1993). Electrical properties of grains and seeds are changing during their storage and that is why we should use them at the determination of examined material various characteristics (Hlaváčová and Muchová, 2005). They are used at the indication of moisture contents during storage to keep it on optimal value, for example Lepack (1998) used measurement of the resistance in potato storage, Gordeev (1998) used electrical properties at the detection of occurrence of sound, diseased and damaged fruit for different storage periods.

## MATERIAL AND METHODS

The measurements were done on the rape oil-seeds *Brassica napus,* L. and common sunflower seeds *Helianthus annus,* L. removed from the large-capacity steel store in Hontianske Nemce and wheat grains mixture *Triticum aestivum* L. from the concrete silo with active ventilation in purchase corporation in Rybany during storage. The system of active ventilation starts in dependence on external temperature, on humidity of air and on moisture of the stored grains or seeds which were measured within silo. Terms of the wheat grains removing: July 17, 2003 at the storage beginning, September 12, November 11, February 2, 2004, May 7 and August 23 at storage finishing. The time of oil seeds storing was short because of material absence which was caused by a low crop. Terms of the rape oil seeds removing: July 10, September 12, 2003. Terms of sunflower seeds removing: October 20, December 4, 2003, April 27, 2004. Average samples were removed from the operating boxes. Moisture content was determined according to standards ISO 712 and ISO 665. Average bulk density of the wheat grains was 786 $kg.m^{-3}$, for rape seeds 633 $kg.m^{-3}$ and sunflower seeds 411 $kg.m^{-3}$. The samples of grains and seeds were placed in the sensor with parameters: diameter of electrode 37.8 mm, electrodes spacing 49.2 mm, mass of empty sensor 208.89 g.
Electrical capacitance and loss factor were measured by LCR meter GoodWill LCR-819 at frequencies of 100 Hz, 500 Hz, 1 kHz, 3 kHz, 10

kHz, 50 kHz and 100 kHz after various time of storage in silo. The samples were granular material that means a mixture of grains and air. The permittivity of this type of the material can be described by equation of Thakur and Holmes (2001)

$$e^{\alpha \varepsilon_{eff}} = v_1 e^{\alpha \varepsilon_1} + (1 - v_1) e^{\alpha \varepsilon_2}$$

where: $\varepsilon_1$ – relative permitivity of grains, $\varepsilon_2$ – relative permitivity of air, $\varepsilon_{eff}$ – relative permitivity of their mixture, $v_1$ – volume fraction of the grains, $\alpha$ - constant.

The chemical composition of long-term stored wheat grains was changing too. We measured the crude protein content, wet gluten content, starch content, falling number (for indirect determination of α-amylases activities) and crude fibrous material (created especially by cellulose, by fraction of hemicelluloses and lignin) content in wheat grains according to standards. The content of fatty acids especially linolenic acid and oleic acid was monitored by chromatographic method.

RESULTS AND DISCUSSION

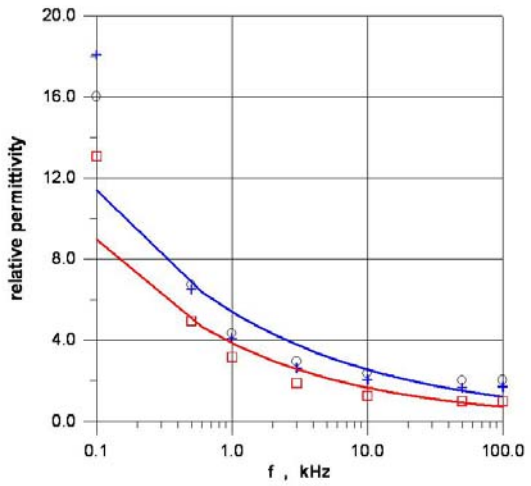


Fig. 1: The frequency dependencies of relative permittivity for sunflower seeds in terms - at moisture content - at oleic acid content
1) October 20, 2003 – 5.08 % – 30.705 % (o),

2) December 4, 2003 – 5.55 % – 32.348 % (+),
3) February 27, 2004 – 5.02 % – 30.470 % (□)

Frequency dependencies of electrical capacitance, loss factor and relative permittivity were determined for all samples of grains and seeds at several times of storage. The capacitance has lower values at all frequencies after longer time of storage and also at lower moisture content and oleic acid content. The capacitance with frequency decreases powerly. In Fig. 1 the frequency dependencies of the relative permittivity for sunflower seeds at moisture content of 5.08 %, 5.55 % and 5.02 % are shown. The relative permittivity has lower values at all frequencies after longer storage and also at lower moisture content and oleic acid content.
The relative permittivity with frequency decreases powerly and the regression equation is

$$\varepsilon_r = \varepsilon_{r1} \left( \frac{f}{f_1} \right)^{-k} \qquad (1)$$

where: $\varepsilon_r$ – relative permittivity, $\varepsilon_{r1}$ – relative permittivity at the reference frequency, $f$ – frequency, $f_1$ = 1 kHz, $k$ – constant. Regression equation has high coefficients of determination for all samples. Regression equation for the capacitance has similar shape. All dependencies have the same character. The chemical composition of long-term stored wheat grains was changing too.

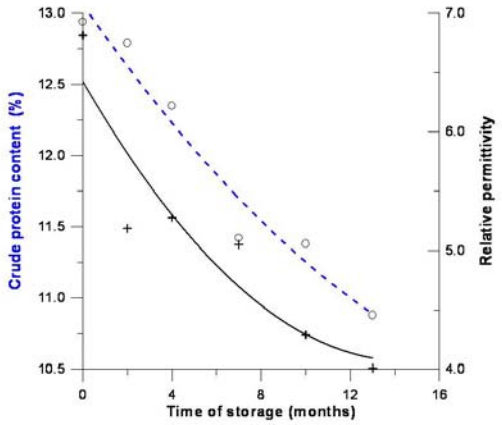


Fig. 2: Changes in crude protein content (o) and in relative permittivity (+) during the storage for wheat grains at frequency of 3 kHz

Tab. 1: Changes of wheat grains some chemical components

| Date | Moisture content % | Wet gluten % | Crude protein % |
|---|---|---|---|
| 17. 7. 03 | 11.85 | 26.19 | 12.94 |
| 12. 9. 03 | 11.63 | 26.30 | 12.79 |
| 11. 11. 03 | 13.20 | 26.10 | 12.35 |
| 27. 2. 04 | 13.05 | 23.85 | 11.42 |
| 7. 5. 04 | 12.85 | 23.44 | 11.38 |
| 23. 8. 04 | 12.00 | 20.16 | 10.88 |

| Date | Falling numbers | Starch % | Crude fibrous material % |
|---|---|---|---|
| 17. 7. 03 | 347 | 67.43 | 2.86 |
| 12. 9. 03 | 349 | 66.26 | 2.82 |
| 11. 11. 03 | 276 | 64.63 | 2.80 |
| 27. 2. 04 | 350 | 63.95 | 3.35 |
| 7. 5. 04 | 370 | 63.26 | 2.87 |
| 23. 8. 04 | 350 | 63.15 | 2.73 |

The correlation between changes in electrical properties and in chemical composition was searched. For illustration, in Fig. 2 changes in crude protein content and in relative permittivity are shown.
These dependencies can be approximated by regression equation in the shape

$$\varepsilon_r = k_o + k_1 \frac{t}{t_1} + k_2 \left( \frac{t}{t_1} \right)^2 \qquad (2)$$

where: $k_o$, $k_1$, $k_2$ – coefficients of regression equation, $t$ – time of storage and $t_1 = 1$ month.

Coefficients of determination have high values. The relative permittivity decreases with storage time according to quadratic function. The crude protein content and starch content decrease with storage time according to quadratic function too and that is why exists a correlation

between changes in relative permittivity and in crude protein content and in starch content during storage.

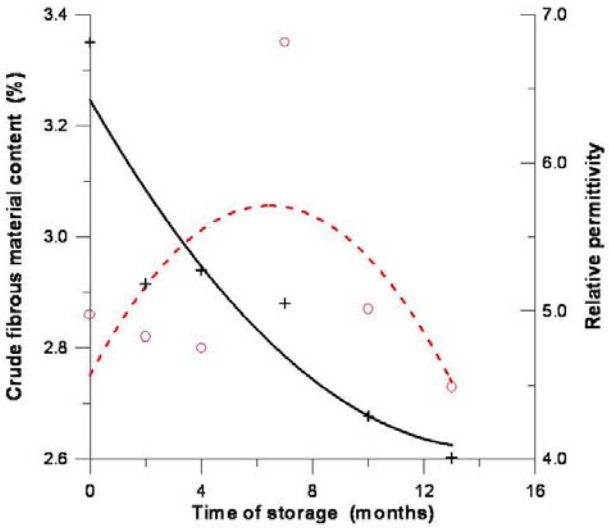


Fig. 3: Changes in crude fibrous material content (o) and in relative permittivity (+) measured at frequency of 3 kHz during storage

Between the changes in relative permittivity and the wet gluten content, crude fibrous material content (Fig. 3) and respectively falling number a correlation do not exists.

The stability of fat component is important in stored oil-seeds and it is longer at higher content of the oleic acid. The changes in content of fatty acids which could influence technological quality of oil-seeds were not occurred during storage.

## CONCLUSION

The temperature and moisture content affect quality of stored material and economy of storage. Electrical properties of grains and seeds are changing during their storage and that is why we should use them at the determination of examined material various characteristics.

The capacitance and relative permittivity decrease powerly with frequency according to Eq. 1. Results showed that specific changes occurred in quality of all wheat grains components – proteinic profile and saccharide complex during 13 months of holding and under condition of

active ventilation too. The relative permittivity decreases with storage time according to quadratic function (Eq. 2). The crude protein content and starch content decrease with storage time according to quadratic function too and that is why a correlation exists between changes in relative permittivity and in crude protein content and in starch content during storage. Between the changes in relative permittivity and the wet gluten content, crude fibrous material content and falling number respectively a correlation do not exists. It was impossible to create the time dependencies for oil-seeds because of short time of storage. The changes in content of fatty acids which could influence technological quality of oil-seeds were not occurred during the storage.

It is usually necessary to measure the electrical properties under the particular conditions of interest to obtain reliable data.

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## ÉLELMISZER FIZIKA KÖZHASZNÚ ALAPÍTVÁNY

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# THE EXPLOITATION POSSIBILITY OF DOMESTIC WHEAT CULTIVARS

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## ABSTRACT

The infection of wheat by the field fungus influences its yields, the total quality and the hygienic accurance. At the mill, the cleaning process is not sufficiently effective, so the well developed, but infected kernels are present in the mass in front of the first grinder.

The results from the investigations have shown that the fungus of the species *Fusarium* are the most present contaminants, and the most present among them was F. oxysporum. Besides the fuzariums the fungus of the genus *Altenaria* were also present. At the most contaminated kernels their matabolits were isolated. The influence of the of the micotoxins *Zearalenon* and *Ohratoxin A* on the wheat quality was determined by the changes of the technologycal quality and the hygienic accurance.

## INTRODUCTION

Cereals, especially the wheat as the basic bread cereal, represent important strategic row material from the aspect of the importance for the nutrition of the nation. All its ptroducts which are using in the human nutrition, can be contaminated by molds at the all phases of the production cycle. Many of those molds are toxigen and are potential producers of various mycotoxins. The contaminated wheat batchs are accepted at the all acceptance points of the processing industry, without any sanitary control.

The aim of the investigation in this study was to investigate the presence of molds in the wheat kernel and flour with identification of the species from the isolated micropopulations, first of all of the toxigenic

species, as well as to be determined their influence on the usability and the hygyenic accurance of the wheat kerenel.

## MATERIAL AND METHODS

In this study the results of the investigation on wheat varieties are presented, at which the attack of *Fuzarium spp.* and *Alternarie* was recorded. The kernel fractionation was performed on the basis of the sensorial evaluation, as well as of mycological and toxycological check. The contaminated kernels are devided into three fractions:

**Darkgerm kernels** at which was registered the colour change of the outer layers, mostly in the germ area and the crease of the potbellied part (1).

**Little fuzarious kernels** are weekly wrinkled kernels with less expressed white and pink coating.

**Strong fuzarious kernels** are expresssively wrinkeled white and pale red and light kernels (2,3).

At the reception acceptance very often commes wheat mixture which contains all the tree contaminated fractions and the sound kernels, which are used as a control sample. It is unknown which ratio of the tree kernels fractions is processed into the type flour at the mill, and continues into the final products which are consumed by the man. But, at the integral milling all of the kernel mass is milled and processed into bread and other bakinf products. All kernel categories are analysed by the official mycologycal, mycotoxycologycal, biologycal, physical-chemical, biochemical and rheologycal methods (4,5).

## RESULTS AND DISCUSSION

**Mycopopulation of wheat kernels:** The results of investigation of the number of molds per wheat kernel, performed in the frame of this study, are presnt in the Table 1. The most infected were the strong fuzarious fractions (Table 1).

**Mycotoxicologycal contamination of wheat:** In the Table 2 are presented the results of investigation of AB1, AG1, OA and ZEA in the wheat kernels. CA was present in slightly and strong fuzarious fractions,

and ZEA which was found even in the 87% of the patterns its concentrations were too high.

Table 1. Average content of mold number per kernel of wheat fraction pattern

| Fraction name | 1 | 2 | 3 |
|---|---|---|---|
| Sound | 0,92 | 0,73 | 0,83 |
| Dark-germ | 2,00 | 2,97 | 2,94 |
| Slightly fuzarious | 2,87 | 3,12 | 3.21 |
| Strong fuzarious | 3,21 | 3,25 | 3,25 |

Table 2. Contamination of wheat kernels by mycotoxins

| Fraction name | Variety | Mycotoxin (ηg . $kg^{-1}$) | | | |
|---|---|---|---|---|---|
| | | Alfatoxins | | Ohratoxin A | Zearalenon |
| | | $B_1$ + | $G_1$ | | |
| Sound | 1 | 0 | 0 | 0 | 500 |
| Dark-germ | 1 | 0 | 0 | 0 | 0 |
| Slightly fuzarious | 1 | 0 | 0 | 0 | 260 |
| Strong fuzarious | 1 | 0 | 0 | 0 | 1400 |
| Sound | 2 | 0 | 0 | 0 | 250 |
| Dark-germ | 2 | 0 | 0 | 0 | 180 |
| Slightly fuzarious | 2 | 0 | 0 | 0 | 270 |
| Strong fuzarious | 2 | 0 | 0 | 48 | 350 |
| Sound | 3 | 0 | 0 | 0 | 0 |
| Dark-germ | 3 | 0 | 0 | 0 | 180 |
| Slightly fuzarious | 3 | 0 | 0 | 32 | 200 |
| Strong fuzarious | 3 | 0 | 0 | 48 | 280 |

The regulation issues the maximal aloweded concentration for the CA till 10 (g/kg) and for the ZEA till 1 (g/kg). Mycotoxins are included in the expressively termostable compounds, because they do not loose their toxicity during the termal processing.

**Biologycal quality of wheat:** The energy of sprouting and sprouting of the sound and darkgerm fractions had normal values, as can be seen on the Table 3. These values significantly decrease at the fuzarious fractions, the high fungus contamination influences badly on the

biologycal reproduction. The consequence of that is the increased share of the abnormal number of sprouts and sick kernels.

Table 3. Survey of biologycal properties of wheat varieties

| Kernel fractions | Sprouting energy (%) | Sprou-ting (%) | Types of sprouts | | | |
|---|---|---|---|---|---|---|
| | | | normal | abnormal | sick kernels | fresh kernels |
| Average sample | 44 | 44 | 40 | 4 | 56 | 0 |
| Sound fraction | 96 | 100 | 80 | 20 | 0 | 0 |
| Dark-germ | 88 | 96 | 90 | 6 | 4 | 0 |
| Slightly fuzarious | 64 | 64 | 60 | 4 | 32 | 4 |
| Strong fuzarious | 0 | 0 | 0 | 0 | 100 | 0 |

The greatest yield was obtained at the sound fractions, while the smallest at the strong fuzarious (Table 4), what is back proportional with ash content (Table 5). At the strong fuzarious fractions was registered the smallest flour yield and the highest ash content, what is an undesirable property from the aspect of milling processing.

Table 4. Level of flour yield of the investigated wheat fractions

| | Flour yield of fractions (% ) | | | |
|---|---|---|---|---|
| Variety | Sound | Dark-germ | Slightly fuzarious | Strong fuzarious |
| 1 | 65 | 60 | | 50 |
| 2 | 55 | 53 | 52 | 50 |
| 3 | 50 | 49 | 48 | 45 |

Table 5. Content of mineral substanses in wheat fractions

| | Ash content (% / s.m.) | | | |
|---|---|---|---|---|
| Variety | Sound | Dark-germ | Slightly fuzarious | Strong fuzarious |
| 1 | 0,88 | 0,89 | 0,90 | 0,97 |
| 2 | 0,90 | 0,93 | 0,96 | 0,96 |
| 3 | 0,94 | 0,95 | 0,98 | 0,98 |

**Chemical methods** clear point out to the disturbances which happen in the wheat conglomerate of gluten and starch provoked by the contamination of molds (protein content, wet gluten content and other).

Table 6. Protein content in wheat fractions

| | Protein content (% / s.m.) | | | |
|---|---|---|---|---|
| Variety | Sound | Dark-germ | Slightly fuzarious | Strong fuzarious |
| 1 | 13,3 | 13,7 | 13,8 | 13,9 |
| 2 | 13,6 | 14,0 | 14,5 | 14,9 |
| 3 | 14,0 | 14,6 | 14,8 | 15,0 |

The all investigated wheat varieties had relatively high protein content at the level of the I technologycal group at the all fractions, and the highest concentrations were registered at the strong fuzarious fractions (Table 6).

**The wet gluten content** of the all analysed varieties has shown considerable variations in the analysed fractions. The darkgerm fractions at the all varieties had the highest values of this rheologycal indicator, and the strong fuzarious fractions the smallest (Table 7). It is probably a consequence of a high mold contamination which have caused changes in the gluten stucture destroying one of the important gluten components-the glutenin fraction which gives to dough the elasticity.

Table 7. Wet gluten content in the wheat fractions

| | Wet gluten content (%) | | | |
|---|---|---|---|---|
| Variety | Sound | Dark-germ | Slightly fuzarious | Strong fuzarious |
| 1 | 32 | 33 | 3 0 | 26 |
| 2 | 33 | 35 | 31 | 27 |
| 3 | 34 | 36 | 32 | 30 |

Besides the differences in the wet gluten quantity, in the analysed fractions can be also emphasized the difference in regard to its quality. Gluten of the sound fractions show good flexibility, small stickiness and plasticity, as well as light yellow colour. Gluten quality of darkgerm and slight fuzarious fractions has decreased, while at the strong fuzarious kernels has shown the weekest rheologycal characteristics (sticky, brittle and incoherent gluten with dark gray colour).

## CONCLUSIONS

On the basis of the results obtained during these investigations, the following can be concluded:

- Molds are frequent contaminents of wheat kernel and bread, which sometimes have the ability for production of mycotoxins;
- The attack of the field molds, especially fuzarious and representatives of the genus Alternaria, decrease the total quality of the wheat kernel, what less-more depends on the share of the contaminated kernels and the degree of their infection;
- The field molds with their philaments decompose the wheat kernel and with this they decrease or lead to unusage of the biologycal and procssing quality and the hygienic accuarance.
- The molds and their methabolits-mycotoxins in the kernel, flour as well as in the bread and baked goods, can not be seen and felt, but they settle with years in the human organizm and in a corresponding moment (immunity decrease) can influence on the appearance of difficult diseases.

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# TEXTURE PROPERTIES OF HORTICULTURAL PRODUCTS

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## 1. INTRODUCTION

The quality of horticultural produces can be determined either by laboratory measurements, or by sensory qualification. Relationship was found between the two methods. Cucumbers and disease resistant apples varieties were tested. The experiments were sponsored by OTKA (TO30241).

First of all the consumers determined sensory points or sensory rank scores. During organoleptical analysis we measured the rheological properties. The sensory evaluation was done by Z. Kókai.

## 2. MATERIALS AND METHODS

Texture point of preserved cucumber varieties and rank scores of apple varieties were determined. Force and time of biting and chewing are characterized by the organoleptical texture properties. We used penetrometrical texture analysis for laboratory qualification.

In our earlier experimental results the ratio (called limit force-number) of the bioyield and rupture stress of the texture curve is a characteristic of the biting forces as well.

The creep property of chewing is specifically important if the average and standard deviation of the limit force-number will be a probability variable that can be seen in the equation. The 95 percent probability level of this variable is used in agrophysical models.

$$\mathbf{X}=\overline{\xi}_{\frac{F_r}{F_y}}+2\mathbf{s}^*_{\frac{F_r}{F_y}}$$

The relationship of these interval length and organoleptical properties was defined by creep function with regression analysis.

$$\mathbf{K}=\frac{\mathbf{X}}{\mathbf{cX}+\mathbf{d}}$$

**K: texture point**

In this function the texture point was used directly by the results of consumers' sensory evaluation. With rank scores before the test of creep-function the quality property (texture point) was defined by PQS method.

## 3. RESULTS AND DISCUSSION

The limit force-number of cucumber varieties is smaller in case of bigger organoleptical points as it can be seen in Table 1.

Table1. Connection between stress ratio and the sensory points.

| Variety | Ratio of limit stresses (limit force-number) $\frac{\sigma_r}{\sigma_f}=\mu$ | Rate of measuring results in interval | | Average of organoleptical point |
|---|---|---|---|---|
| | | Row (%) | Preserved (%) | |
| Levina | 1,2 < μ < 3,5<br>2 < μ < 6 | 52 | 56 | 7,4 |
| Minerva | 1,2 < μ < 3,5<br>2 < μ < 6 | 97 | 89 | 6 |

The rank scores of apple varieties are shown in Table 2. In the first quarter of the rectangular coordinate system we show the vectors with

frequency (number of consumers) of rank scores (can be seen in Figure 1).

Table2. Sensory rank scores of the consumers varieties by varieties.

| Variety | | Number of consumers | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | according to rank scores | | | | | | Total |
| | | 1. | 2. | 3. | 4. | 5. | 6. | |
| | | Rank score | | | | | | |
| 1 | Releika | 11 | 11 | 10 | 12 | 11 | | 55 |
| 2 | Relinda | 17 | 11 | 1 | 11 | 6 | 46 | 92 |
| 3 | Remo | 9 | 15 | 10 | 19 | 25 | 14 | 92 |
| 4 | Renora | 11 | 10 | 22 | 28 | 15 | 6 | 92 |
| 5 | Resi | 13 | 8 | 12 | 15 | 7 | | 55 |

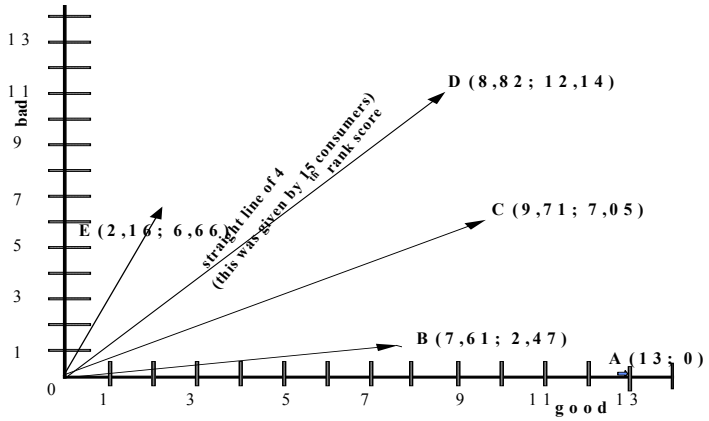


Figure 1.
Representation of sensory rank scores with vectors

We presented PQS method for RESI apple variety in Figure 2. The organoleptical property (organoleptical point) is tangent of the directional angle of center of gravity. These properties were used in creep-function (can be seen in Figure 3.), which divides into two quality groups the apple varieties (can be seen in Figure 4. too).

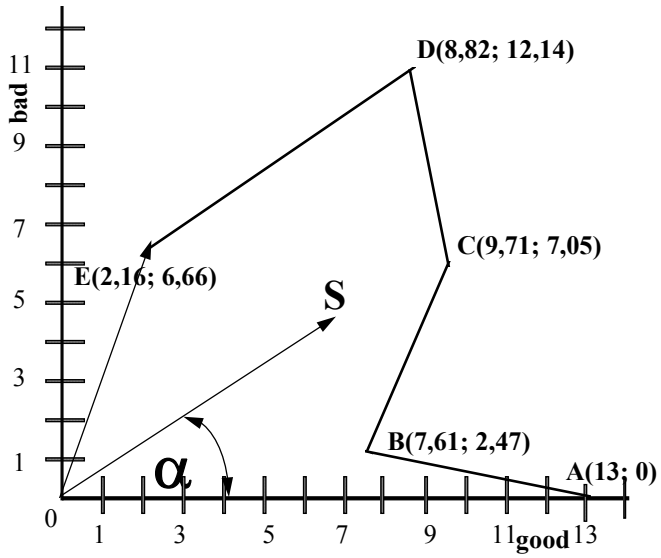


Figure 2.
Determination of centre of gravity

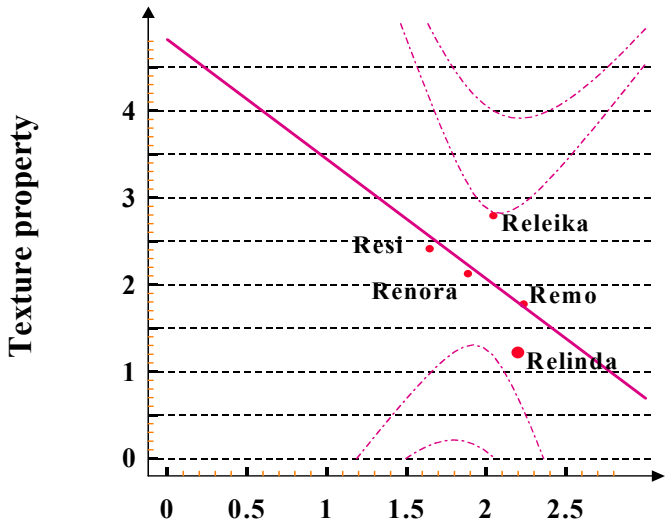


Figure 3.
Correlation of the rheological properties and sensory rank scores
(Y=—1,0723X + 4,1637, r=0,9988 )

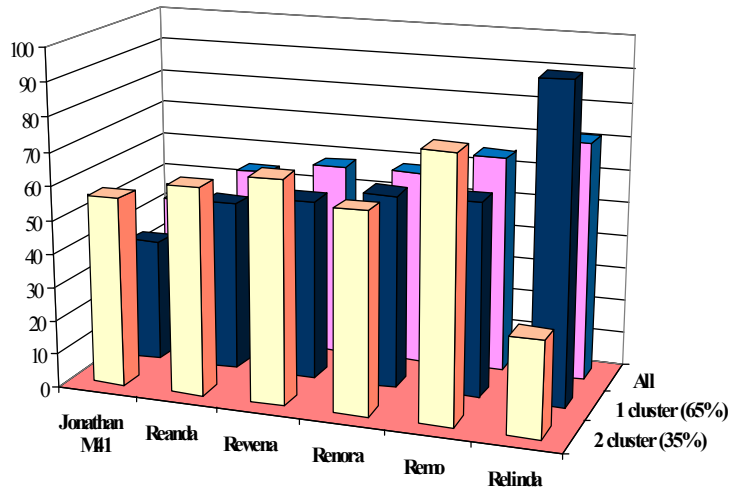


Figure 4.
Preference rank of apple varieties

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# PHYSICAL PARAMETERS OF SEA BUCKTHORN BERRIES

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## ABSTRACT

Physical characteristics of sea buckthorn berries in nine different varieties in two different years (1998 and 2005) grown in Estonia are described.

The moisture content, dimensions and size distribution of the berries and also puncture resistance are determined. The moisture content of the berries is in the range of 80-87%. The geometric mean diameter of the berries varies from 8.64 to 12.57 mm. The lowest value of puncture resistance is 199 g and the highest is 304 g. The freezing has some influence on puncture resistance.

## INTRODUCTION

Sea buckthorn (*Hippophae rhamnoides* L., *Elaeagnaceae*) is a temperate bush native to Europe and Asia (Rousi, 1971). It was used as a medicinal plant in Tibet already in 900 A.D. (Lu, 1992). In addition to the medicinal use, the berries of sea buckthorn can be processed into products such as juice and marmalade, and be used for flavouring of dairy products because of the unique taste of sea buckthorn berries. Today it is used as a potential functional food ingredient; the berries are especially rich in vitamin C and flavonoids.

During the last 10 years the cultivation of sea buckthorn in Estonia has become more popular – nowadays sea buckthorn plantations exceed 500 ha. Developed under leading professor Trofimov in institute at the Botanic Garden of Moscow University sea buckthorn varieties have mostly been planted in Estonia.

Berries firmness is one of the most important characteristics for a fresh market cultivar, which is related to both the stage of maturity and the variety itself. Harvested sea buckthorn berries undergo various processing operations both on the estate and in the factory, requiring basic information on the physical properties of the sea buckthorn berries. The

study on physical properties, such as size, weight and crushing strength of berries are required for the development of the grading system for berries.

The objectives of this work were to evaluate fruit firmness and fruit retention strength in different sea buckthorn varieties.

## MATERIALS AND METHODS

### Materials

Sea buckthorn berries were harvested in September 1998 and 2005 from different cultivars grown in Estonia (marked as BOL – Botanicheskaja Ljubitelskaja, VOR - Vorobjevskaja, AVR - Avgustinka, TRR - Trofimovskaja, PSR – Podarok Sadu, OTR – Otradnaja, BOR – Botanicheskaja, HPR – Gibrid Pertchika, PER – Podarok Sadu). After some experiments the berries were kept frozen for further studies at -40° C. The fruits were cleaned to remove foreign matter.

### Methods

Moisture content

The moisture content was characterized using halogen moisture analyser HR83 (Mettler Toledo, Switzerland). The average values of three replications are reported.

Dimensions and size distribution of fruit

In order to determine the size and shape of the fruit, three principal dimensions, namely length, width and thickness, were measured using a micrometer. The geometric mean diameter ($D_g$) of the fruit was calculated by using the following relationship (Mohsenin, 1970):

$$D_g = (LWT)^{\frac{1}{3}} \qquad (1)$$

where $L$ is the length, $W$ is the width and $T$ is the thickness.

According to Mohsenin (1970), the degree of sphericity ($\Phi$) can be expressed as follows:

$$\Phi = \left( \frac{(LWT)^{\frac{1}{3}}}{L} \right) * 100 \qquad (2)$$

This equation was used to calculate the sphericity of fruits in the present investigation.

To obtain the mass of the berries, 30 fruits were weighed by a chemical balance AB204 (Mettler Toledo, Switzerland) reading to an accuracy of 0.0001g before they were frozen.

Puncture resistance

The puncture resistance of sea buckthorn berries was characterized using a texture analyzer TA-XT2i (Stable Micro Systems, UK).

The measurements at constant rate 1 mm/s were made with a 5 mm cylindrical probe. The samples were placed centrally on the blank plate, secured on the heavy duty platform, and the probe penetration test is commenced around the mid region of the fruit. The maximum force required to make the puncture on the fruit surface was taken from the force–time curve as shown in Fig. 1. The puncture resistance was measured with 15 fruits (replications) and average values were reported.

## RESULTS AND DISCUSSION

Moisture content

The moisture content was measured in all nine species of sea buckthorn berries. The average values of three replications are reported and are presented in Table 1. The values are in the range of 84.12-86.87 % and 80.33-85.82 % in 1998 and 2005, respectively.

Table 1 The moisture content and the mass of the berries collected in autumn 1998 and 2005

| Sea buckthorn berry variety | Moisture content, % | | Mass of the berries, g | |
|---|---|---|---|---|
| | **1998** | **2005** | **1998** | **2005** |
| AVR | 86.87 | 85.82 | 0.57 | 0.60 |
| BOL | | 83.66 | | 0.76 |
| BOR | 86.86 | | 0.52 | |
| HPR | 84.75 | | 0.69 | |
| OTR | | 82.41 | | 0.65 |
| PER | 85.25 | | 0.57 | |
| PSR | 86.03 | 80.33 | 0.50 | 0.49 |
| TRR | 84.12 | 83.45 | 0.65 | 0.85 |
| VOR | | 83.83 | | 0.76 |

Dimensions and size distribution of fruit

Three principal dimensions, namely length, width and thickness, were measured using a micrometer. These data are given in Table 2. The length of the berries is between 12.19-15.24 mm in 1998 and 10.64-13.71 mm in 2005, the longest berries in 1998 are in Pertchika variety and the shortest are in Podarok Sadu variety, but in 2005 Botanitcheskaja Ljubitelskaja and Podarok Sadu, respectively. The width of the berries is in the range of 9.23-11.69 mm in 1998 and 7.79-9.03 mm in 2005, the widest berries in 1998 are in variety Avgustinka and the narrowest are in variety Pertchika, in 2005 Trofimovskaja and Podarok Sadu, respectively.

Table 2 Dimensions and size distributions of sea buckthorn berries

| | Year | Length, mm | Width, mm | Thickness, mm |
|---|---|---|---|---|
| AVR | 1998 | 14.53±0.44 | 11.69±0.36 | 11.69±0.36 |
| | 2005 | 10.77±0.49 | 8.69±0.42 | 8.69±0.42 |
| BOL | 2005 | 13.71±0.67 | 8.60±0.41 | 8.60±0.41 |
| BOR | 1998 | 12.30±0.67 | 9.78±0.54 | 9.78±0.54 |
| HPR | 1998 | 14.39±0.80 | 10.91±0.50 | 10.91±0.50 |
| OTR | 2005 | 12.14±0.56 | 8.52±0.40 | 8.52±0.40 |
| PER | 1998 | 15.24±0.63 | 9.23±0.27 | 9.23±0.27 |
| PSR | 1998 | 12.19±0.66 | 9.44±0.37 | 9.44±0.37 |
| | 2005 | 10.64±0.51 | 7.79±0.36 | 7.79±0.36 |
| TRR | 1998 | 13.81±0.76 | 10.43±0.58 | 10.43±0.58 |
| | 2005 | 13.64±0.50 | 9.03±0.21 | 9.03±0.21 |
| VOR | 2005 | 12.52±0.56 | 8.47±0.38 | 8.47±0.38 |

| | Year | Geometric mean diameter, mm | Sphericity, % |
|---|---|---|---|
| AVR | 1998 | 12.57±0.34 | 86.53±1.81 |
| | 2005 | 9.34±0.40 | 86.75±2.48 |
| BOL | 2005 | 10.01±0.43 | 73.43±1.83 |
| BOR | 1998 | 10.55±0.53 | 85.85±2.88 |
| HPR | 1998 | 12.00±0.53 | 83.43±2.07 |
| OTR | 2005 | 9.60±0.38 | 79.27±2.81 |
| PER | 1998 | 10.90±0.30 | 71.59±2.06 |
| PSR | 1998 | 10.28±0.42 | 84.36±2.13 |
| | 2005 | 8.64±0.36 | 81.20±2.43 |
| TRR | 1998 | 11.46±0.64 | 82.92±2.62 |
| | 2005 | 10.36±0.25 | 75.99±1.57 |
| VOR | 2005 | 9.65±0.40 | 77.13±2.14 |

According to the formula 1 calculated geometric mean diameter is between 10.28-12.57 mm in 1998 and 8.64-10.36 mm in 2005, largest value belongs in 1998 to Avgustinka variety, the smallest value to Podarok Sadu, in 2005 Trofimovskaja and Podarok Sadu, respectively.

Sphericity is calculated on the assumption of formula 2. The certain values are given in Table 2. This formula takes into account the length, width and thickness of the berries and as a result it is possible to evaluate the shape of the berries. Most spherical berries in 1998 are in Avgustinka variety; simultaneously most oval berries are in variety Pertchika, in 2005 also Avgustinka and Botanitcheskaja Ljubitelskaja, respectively.

Also the mass of the berries is given in Table 1. The lightest berries in 1998 are in Podarok Sadu variety (0.51 g), in 2005 the same variety has the lightest berries (0.49 g). Variety Gibrid Pertchika in 1998 and Trofimovskaja in 2005 have the heaviest berries, 0.71 and 0.85 g, respectively.

Puncture resistance

A typical force-time curve for puncture resistance of sea buckthorn fruit is shown in Figure 1. When the probe moves down onto the fruit, a rapid rise in force is observed. During this stage the sample is deforming under the applied force but there is no puncturing of the tissues.

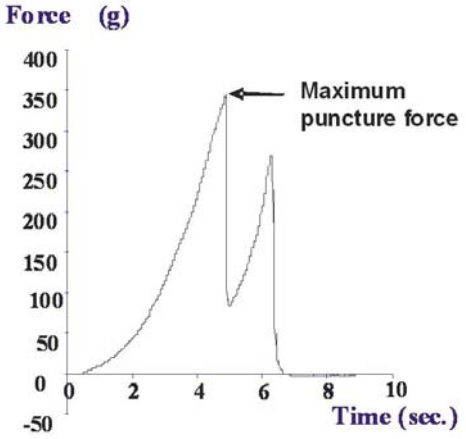


Figure 1
A typical force-time curve for puncture resistance of sea buckthorn fruit (5 mm diameter solid cylindrical probe, speed: 1 mm/s).

This stage ends abruptly when the probe punctures through the skin and begins to penetrate into the internal tissue of the sample, often called the bioyield point. The bioyield point occurs when the probe begins to penetrate into the fruit, causing irreversible damage. The first peak is the force required to puncture the surface of the sample. The second peak is obtained as a result of the prongs penetrating through the lower surfaces. This peak is due to the movement of the prongs towards the base plate.

It is usually desired that, whilst being ripe, the fruit still maintain a high degree of mechanical strength to protect the fruit from damage, such as bruising during transport and handling. The rupture force of sea buckthorn berry varieties before and after freezing in two different years is shown in Figure 2.

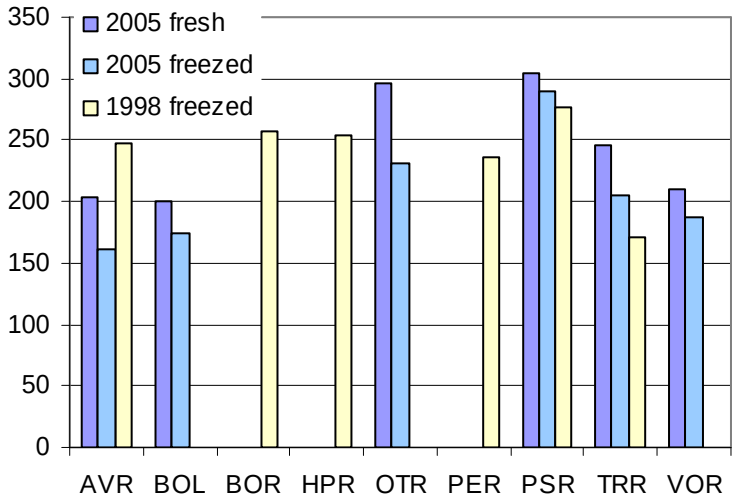


Figure 2
The rupture force of sea buckthorn berries (g)

As it can be seen, the strongest fruits were from the Podarok Sadu variety (303.87 g) and the weakest were from Botanitcheskaja Ljubitelskaja variety (199.43 g). The puncture resistance of the berries is influenced by freezing and defrosting, as it can be seen also on Figure 2. The fresh berries are stronger than the berries which are freezed and melted. The puncture resistance decreases after defrosting differently,

variety Otradnaja has the biggest decrease (65 g) of the puncture resistance. As all the characteristics of the berries are influenced by climatic and other conditions, we can see, that the puncture resistance is not the exception – some varieties of berries collected in 1998 have higher values of puncture resistance after freezing than berries collected in 2005 (see Figure 2, variety Avgustinka).

Physical parameters of some sea buckthorn varieties were determined for better variety selection.

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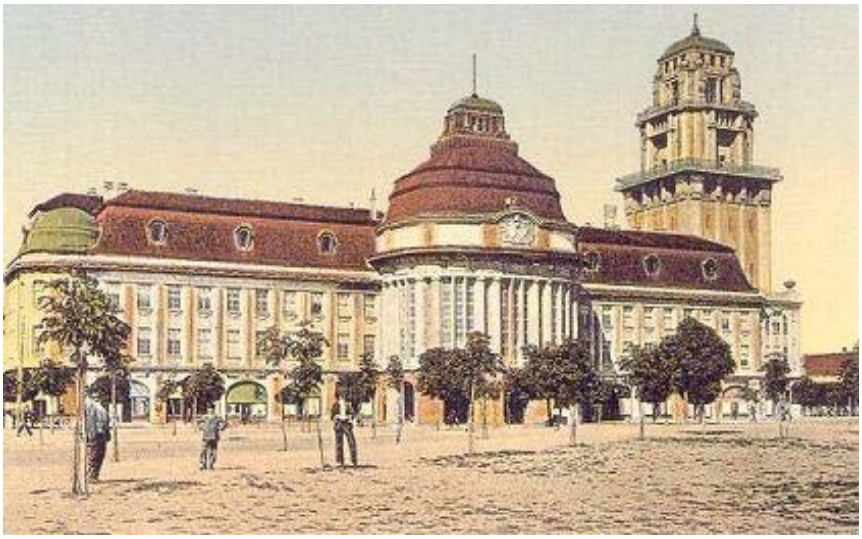

Városháza Zentán régen és ma
City hall in Senta long time ago and today

# CRYSTALLIZATION OF SUGAR SOLUTIONS

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## ABSTRACT

The properties of supersaturated glucose, fructose and sucrose solutions were characterized and the changes appearing in their crystallization investigated. It was found that $a_w$, hardness and stickiness of glucose and fructose solutions were identical. The glucose and sucrose solutions crystallized with one week and one day, respectively. The fructose solution didn't crystallize. During crystallization the water activity of the sugar solutions increased.

## INTRODUCTION

Sugars have frequently been used in food and pharmaceutical fields. The crystallization of sugars is important in the food industry as evidenced by the many processes where the degree of crystallinity of sugars is critical to acceptance of the final product, i.e., storage stability (Gallo et al., 2003). Supersaturation is the major force of crystallization. The appearance of nuclei generally occurs after the organization of hydrated sugar molecules in swarms during the period of pre-nucleation (Hartel, 2001). Temperature of storage, magnitude of temperature fluctuations, and relative humidity can all affect the changes in crystalline structures and rate of crystallization that take place during the storage and distribution of amorphous sugar solutions (Mazzobre et al., 2003). To control the crystalline microstructure in food systems and understanding of the crystallization during processing and storage is required.

The purpose of the present work was to characterize the properties of supersaturated glucose, fructose and sucrose solutions and investigate the changes appearing in their crystallization.

## MATERIALS AND METHODS

### Materials

Crystalline sucrose, glucose and fructose were gift from „Kalev" enterprise.

### Sample preparation

The supersaturated aqueous sugar solutions were prepared from distilled water and crystalline sugars in the stirred boiling vessel by evaporating the water from saturated sugar solutions and cooling solutions down according to the preset temperature profile.

### Methods

Concentration of water was determined using Karl Fischer titrator DL38 (Mettler Toledo, USA) connected to computer. The water activity measurements were performed on the water activity analyser AquaLab CX3 (Decagon, USA).

The hardness and stickiness analysis were performed with a computer-controlled TA-XT2i texture analyser manufactured by Stable Micro Systems (England). This instrument pushed a 3 mm diameter cylinder into a test specimen to a depth 5 mm at a rate of 1 mm/s at 20°C and subsequently moved the cylinder to the starting position.

For microscopy the specimens of sugar solutions were placed on the base glass and the cover glass was tightly sealed with silicone in order to prevent the moisture diffusion.

Three replications were analysed and average values were reported in all analysis.

## RESULTS AND DISCUSSION

The supersaturated sugar solutions were made by heating the aqueous solutions to certain boiling point to give different moisture concentration (Figure 1). The sucrose solution re-crystallized at 120°C and couldn't be saturated to more than 15% water content. In order to characterize the properties of sugar solutions the effect of moisture content on i) water activity, ii) hardness and iii) stickiness was investigated. The water activity was increasing with water content. The sorption isotherms of

glucose and fructose solutions were similar and different from that of sucrose (Figure 2).

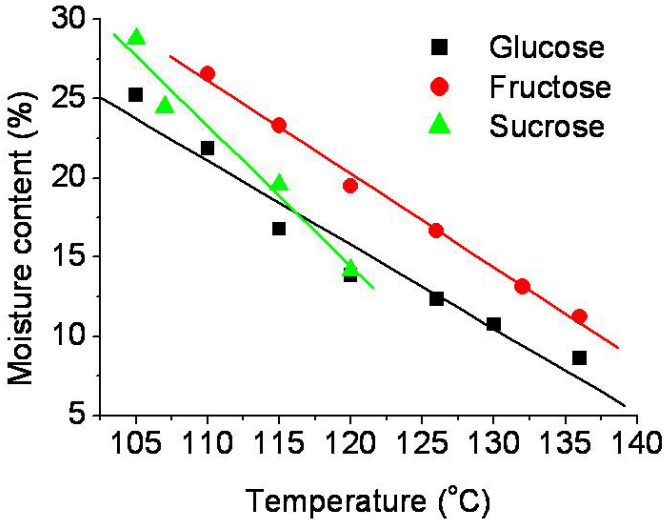


Figure 1. The dependence of water content on the temperature of glucose, fructose and sucrose solutions

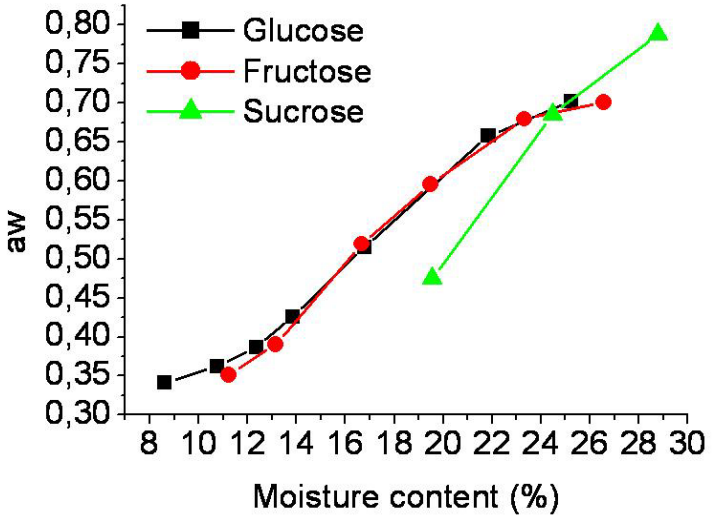


Figure 2. The sorption isotherm of glucose, fructose and sucrose solutions

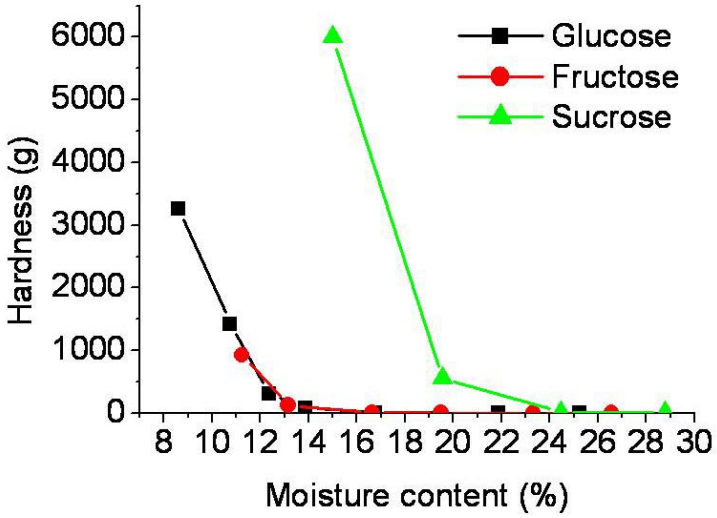


Figure 3. The dependence of hardness on the water content of glucose, fructose and sucrose solutions

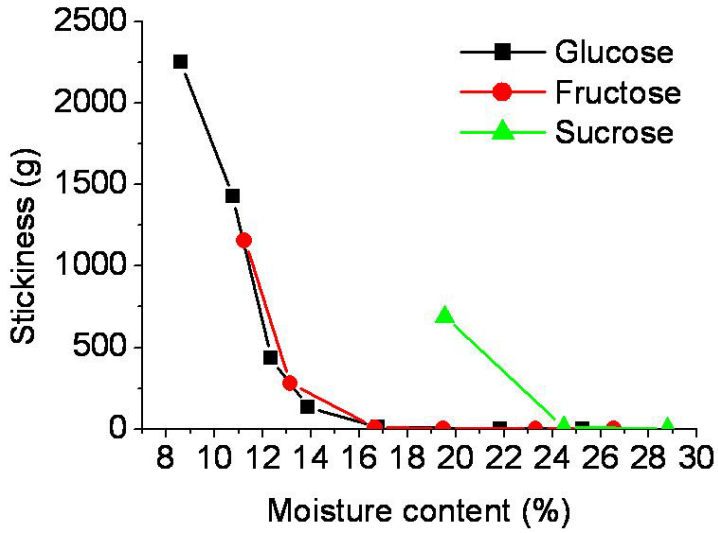


Figure 4. The dependence of stickiness on the water content of glucose, fructose and sucrose solutions

The hardness and stickiness of all sugar solutions were increasing with decreasing the moisture content (Figure 3, 4). For glucose and

fructose the high water content solutions were soft and free flowing. Around 14% of water the solutions became very thick and sticky giving rise of hardness and stickiness. The sucrose solution gave harder and stickier solution already at water content of 24%. The glucose and fructose supersaturated solutions had similar sorption isotherms, hardness and stickiness of the solution.

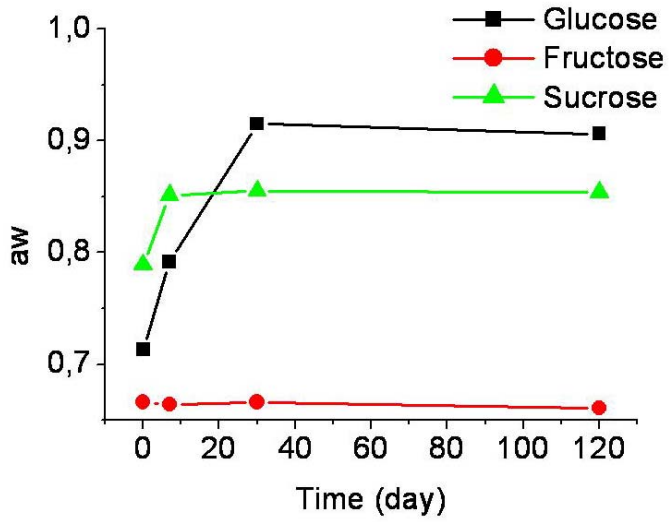


Figure 5. The dependence of water activity on the time of storage of 70% aqueous sugar solutions.

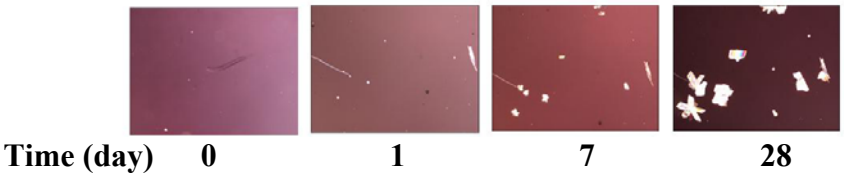


Figure 6. The formation of glucose crystals in time under the microscope

During crystallization process of 70% of water solutions the water activity sucrose solution increased up to equilibrium $a_w$ value in few days and that of glucose to during a month (Figure 5). Figure 6 shows the appearance and growth of glucose crystals under the microscope. It can be seen that for glucose the nucleation happens within 1 week and major

crystallization within 1 month. For sucrose the crystallization take place within 1 day and fructose didn't crystallize.

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# HEALTH ASPECTS OF FOOD RADIOACTIVITY

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ABSTRACT

The aim of the paper was to analyze the results of food radioactivity control in Nis in five year period after the war in 1999 and to identify possible health hazards. The routine food safety control were done in Public Health Institute, Nis from 2000-2004. Samples of food were analyzed in certified institutions of Serbia for radioactivity control by using standard procedure. 676 food samples were controlled (196 domestic and 480 imported food). The radioactivity of analyzed food samples was at the normal environmental levels and we do not anticipate health consequences.

## INTRODUCTION

In Serbia, the monitoring of environment for radionuclides was established in 1963 for the sake of preventive protection of population and environment from the harmful effect of ionizing radiation. The objective of this monitoring programme is to prevent unacceptable damage to environment and human health.

The main pathways of radionuclides in the human body are inhalation and ingestion through food and drinking water. Radionuclides may enter human food chain by direct deposition on the leaves or other parts of plants, by persistence in layers of soil from which they are taken up into growing plants through the roots, by re-suspension as dust from exposed surfaces and from water sources.

The aim of this paper was to present results of the measuring of radioactivity in food between 2000-2004 in Public Health Institute, Nis (Serbia) and to identify possible health hazards.

## MATERIAL AND METHOD

The paper includes data of the samples of food collected from 2000- 2004. in the locations of south-east part of Serbia. The sampling was performed by the Public Health Institute team and the food samples were analyzed by using standard procedure. Each food sample was dried at room temperature, crushed and homogenized. The levels of the natural radionuclides and artificial radionuclides in food were determined by high-gamma spectrometry.

All samples were counted on appropriate geometry (marinelli beakres or other adopted from laboratory) with pure germanium detectors EG&G ORTEC with relative efficiency 255 and resolutions 1,85keV on 1.332 MeV. The detector was contained in 10 cm thick lead well internally lined with cadmium and copper folios. Through a linear amplifier the detector was connected to an 8192 channel pulse height analyzer on line to a PC. Data analysis was performed taking into account sample geometry, self-absorption in the sample and background.

## RESULTS

The total number of samples was 676 (Table 1). The highest number of foods tested for radioactivity was imported foods (71%) and every third sample was from domestic production (29%).

Table 1. Food samples tested for radioactivity in Public Health Institute, Nis

| Year | Domestic samples | Samples of imported foods | Total number |
|---|---|---|---|
| 2000 | 56 | 108 | 164 |
| 2001 | 51 | 44 | 95 |
| 2002 | 51 | 61 | 112 |
| 2003 | 0 | 31 | 31 |
| 2004 | 38 | 236 | 274 |
| ∑ | **196** | **480** | **676** |

The measurements of radioactivity were carried out in the foodstuff characteristic for the national diet of Serbia. The largest number of tested samples were legumes, cereals (18,8 %) and confection (15.2%) (Table 2).

Table 2. Types of foods tested for radioactivity in Public Health Institute, Nis from 2000-2004

| Type of food | Number of tested food samples |
|---|---|
| Cereal,leguminous | 127 |
| Sugar, bombons, chocolate, honey | 103 |
| Fruits | 97 |
| Fishes,shells, crab-fishes | 63 |
| Vegetables | 44 |
| Children foods and dietetic foods | 43 |
| Aditive and spices | 43 |
| Coffee, cocoa, spices | 33 |
| Milk and products of milk | 31 |
| Alcoholic drinks | 22 |
| Ready meals | 19 |
| Cakes | 17 |
| Non alcoholic beverages | 14 |
| Other | 22 |

Gammaspectrometric measurements of food samples evidenced low values of the natural radionuclides, as well as $^{137}Cs$ obtain from the locations in the region of Nis. Presence of the depleted uranium in food products has not been evidenced (Table 3).

Table 3. Specific activity of different radionuclides (average values) in food of Nis from 2000-2004

| Specific activity (Bq/kg) | $^{137}$Cs | $^{40}$ K |
|---|---|---|
| CEREAL | <0.4 | 416±20.85 |
| Legumes | <0.3 | 16.65±0.73 |
| Milk * | <0.2 | 33.5±3.95 |
| Products of milk | <0.5 | 48.4±6.7 |
| Fruit | <0.2 | 14.78±2.22 |
| Vegetables | <0.3 | 61.45±8.95 |
| Sugar | <0.2 | 14.89±0.74 |
| Cakes | <0.1 | 50.97±2.55 |
| Non alcoholic beverages* | <0.3 | 68.95±7.30 |

* (Bq/l)

## DISCUSSION

Mostly of food samples tested for radioactivity in Public Health Institute, Nis from 2000-2004 were imported foodstuffs, as required by regulations (Official Gazette 9/99). It would be very useful to increase the control of the domestically produced food in the future.

On the basis of our measurements, it was concluded that the activity of both natural and long-lived radionuclides of artificial origin ranged within low levels in all food samples. The activity level of radionuclides of all samples was under maximum permitted levels.

The measurements of systematic radioactivity monitoring in period 1999 – 2003 from other part of Serbia showed similar results. They indicated that there were no deviation in the natural radioactivity compared to the foods samples before 1999. The activity levels of fission (artificiale) radionuclides (Cs $^{137}$, Sr$^{90}$) also have very low values (Pantelic et al 2004). The artificial radionuclides could have been ejected in the environment due to nuclear accidents and nuclear weapons use. In 1999, during NATO bombing at the South of Serbia (Vranje), contamination of soil by depleted uranium ammunition was established (UNEP 2002, Pantelic et al 2002) . During 2001 and 2002, the presence

of depleted uranium has not been confirmed in samples of food from this site (Javorina et al 2004) .

The results of systematic radionuclides measurements in Serbia from 1999 showed that the radionuclide $^{137}Cs$ in vegetables, fruits, crops and fresh milk samples was detected below minimum detectable activites (Pantelic et al 2000).

After the Chernobyl accident, out of analized samples of milk, milk products, baby food and human milk in Belgrade, 81,7% had 1000 times greater Cs $^{137}$ specific activity than in the period before the accident (Ajdacic et al.1992).

Compared with other countries, the natural radioactivity levels of food from Nis region market are similar to that of European countries.

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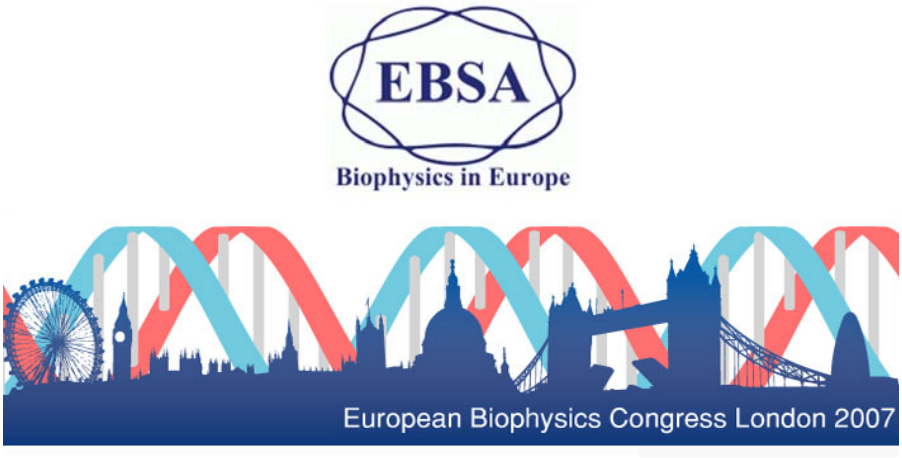


Welcome to the website for the 6th European Biophysics Congress, organised under the auspices of the European Biophysical Societies Association, the British Biophysical Society and Imperial College London. The Congress will take place at Imperial College London, from 14th to 18th July 2007. Important dates:

## Congress dates:

Welcome and first Plenary Lecture: Saturday 14th July 2007
Congress Dinner: Tuesday 17th July 2007
Departure: Thursday 19th July 2007

Abstracts submitted before 1st May 2007 will be published in the Congress Abstracts book, a supplement to the European Biophysics Journal. Each delegate will receive a copy upon arrival. Late abstracts (submitted up to 15 June) will be made available in booklet form to the delegates. Late Registration opens: 1st May 2007. The 7th European Biophysics Congress will be held in Genoa, Italy, from 11th to 15th July 2009. Deadline for applications: 31 January 2007 (requires abstract, letter of recommendation from supervisor, one-page CV and if possible, letter of support from National Biophysical Society).

# PRESERVATION OF FRUITS WITH HOME-MADE DEHYDRATION METHOD

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ABSTRACT

In the paper information is given about the investigations of home-made dehydration of different domestic (apple, plum, sour cherry), subtropical and tropical (lemon, orange, kiwi, banana, pineapple) fruits, preserved by home-made dehydration technique. For dehydration FD-510 type electric heater was used. The content of water in the dehydrated samples was determined in drying owen. The sensory parameters, the rheological properties, the texture and also the storability depend significantly on the water content (and water activity) of the dried fruits.

## INTRODUCTION

The water content of different fruits is significant, in some cases even over 90 %. But from point of view of storability mainly not the water content, but the water activity is dominant. If the water activity is rather low – during the dehydration process the ratio of free water to bounded water changes – the different microorganisms can not grow and develop on the surface of the foodstuffs. Based on the connection between water content and water activity there is a possibility to determine the amount of water, which should be removed from the original foodstuffs or agricultural products during the dehydration process. This is the method and the reason to produce safe food with long storability.

Dehydration is one of the most natural and widely used methods of food preservation technologies(1-3). E.g. solar dehydration is since centuries a simple but very effective technique for increase of the storability of various fruits and vegetables. Dehydration is a typical post-harvest technology with great economic importance. This paper deals

with results of investigations of home-made dehydration technique for domestic, subtropical and tropical fruits(4)(5).

## MATERIAL AND METHOD

The dehydration experiments were carried out with the following domestic and subtropical and tropical fruits:

- apple (Malus domestica)
- plum (Prunus domestica)
- sour cherry (Cerasus vulgaris)
- lemon (Citrus limon)
- orange (Citrus aurantinum)
- kiwi (Actinida chinensis)
- banana (Musa paradisiaca)
- pineaaple (Ananas sativus)

The domectic fruits were grown in Hungary (Szolnok), the subtropical and tropical ones were transported from Greece, China, Italy, Costa Rica and Ecuador.

For dehydration HAUSER FD-510 type equipment (electric heater) was used. This machine is constructed for home-made dehydration of agricultural products with 250 W power. During the drying process – evaporation of water (and partly other volatile components) from the surface of the samples because of heating and ventillation – 2-3 kg fresh fuits in sliced form can be treated in the same time. The slices of fruits or vegetables should be placed on the paralel platters of the equipment. The optimum time requirement depends also on the water content of the samples, in general is between 4 and 10 hours.

Determination of the water-content of the dehydrated samples was carried out in drying owen, using 105 $^{O}$C temperature.

## RESULTS AND CONCLUSIONS

The main aim of dehydration technology is to produce dried fruit products with good sensory properties and acceptable (rather long) storability. If the remaining water content is still relative high, the storability is not too long, although the sensory properties (e.g. softness, elasticity, hardness, taste, colour) are excellent. Of course if we need

longer storability it is necessary to apply longer treatment, as well, this means higher energy requirement and higher tempereature, which can have a negative influence on the quality parameters of the dried fruit products.

The measured water contents of the different dried samples were the following:

| | |
|---|---|
| Apple: | 9.3-14.1 % |
| Plum: | 14.3-18.0 % |
| Sour cherry: | 15.5-18.3 % |
| Lemon: | 21.8-40.0 % |
| Orange: | 24.5-40.5 % |
| Kiwi: | 17.4-18.0 % |
| Banana: | 10.2-13.6 % |
| Pineapple: | 14.2-14.5 % |

During the dehydration process the water content of the original agricultural products decreases but on the other hand the dry material concentration increases. The average enrichment factor for the dry material in the investigated dehydrated fruits was e.g. in case of apple 9.4, in case of banana 3.3 , in case of sour cherry 5.9 and in case of plum 5.5. So it is evident, that in consequence of the dehydration treatment the difference in dry material can be even one order of magnitude in comparison with the original edible fruits.

The dehydrated products with optimum dehydration state have rather good sensory properties and contain practically all the valuable componensts (e.g. dietary fibers, minerals) of the fruits. Further significant adventage of the dehydration process is the reduction of the transport expenses, and the really long storability in normal conditions without special energy-use. Of course the storability depends not only on the water content and water-activity of the dried products but also on the temperature and humidity of the storage room. Let us mention that the storability of the reported dehydrated fruit samples was rather long, in all cases exceeded 3-4 month period at room temperature and 60-70 % relative humidity.

The dehydrated fruits can be used by the consumers directly but also after rehydration, e. g. in form of soups. Rehydration is a physical process antagonistic to the dehydration. During rehydration process of

course the volume of the dried products increases significantly depending on the water-uptake.

We are going to continue the research activity concerning the application of dehydration process for fruits and vegetables. The next topic is the investigation of long-term storability of dehydrated fruits.

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# THIXOTROPIC BEHAVIOUR OF KETCHUP

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## ABSTRACT

Ketchup is a typical food product, which possesses a thixotropic behaviour. The destroying and the recovery of its structure were monitored by rotational viscometry HAAKE VT 550. The Moore model, which describes the thixotropic behaviour by structural parameter $\lambda$, was chosen for fitting the basic rheological curve ($\tau = \tau(\dot{\gamma})$, where $\tau$ is the shear stress and $\dot{\gamma}$ is the shear rate) and the stress-time dependences at different shear rates. As a result the relaxation times at different shear rates were calculated. It was shown as well, that the ketchup possesses a spectrum of relaxation times, expresses as stretched exponent parameter $\beta$. The changes in thixotropic behaviour during storage were also monitored.

## INTRODUCTION

In many industrial materials, the viscosity decreases with time of shearing, but if the shearing is stopped, the viscosity regains the higher value. This behaviour is known as thixotropy and it is found in fluids as well as in semi-solid materials. Thixotropy arises from structural formation due to antiparticle forces acting between dispersed species in a material (Schramm, 1994). It is governed by Brownian motion and shear and leads to the time dependent characteristics.

Ketchup is a typical food product, which possesses a thixotropic behaviour. It is due to agglomeration of fibrous particles and entanglement, which build-up structure at rest, and de-agglomeration and disentanglement under shear.

The main parameters, which affect the rate of structure changes at rest and under shear, are: concentration of the dispersed phase, shape and

size of the particles, size distribution, value of shear rate, internal constitution, etc.

The present work shows a method for characterizing the thixotropic behaviour of ketchup by the use of empiric structural model – lumped parameter model.

## THEORETICAL BACKGROUND OF THE MODEL

In the λ-model all these parameters, affecting the structure changing, are replaced by one structural parameter, defined as follows (Cheng, 1987):

- For fully build up structure, $\lambda = 1$ and the viscosity is maximal $\eta = \eta_\infty + \mathbf{c}$, where **c** is the viscosity increment;
- When the structure is fully broken down $\lambda = 0$ and $\eta = \eta_\infty$;
- For intermediate structures the viscosity is $\eta = \eta_\infty + \mathbf{c}\lambda$, $0 < \lambda < 1$;
- The break-down rate is a power law function of shear rate and depends also on the current structure:

  $\mathbf{break\text{-}down\ rate} = -\mathbf{b}\lambda\dot{\gamma}^{\mathbf{m}}$;
- The build-up rate depends on the amount of structure to be recovered:

  $\mathbf{build-up\ rate} = \mathbf{a}(1-\lambda)$;
- The net rate of change of structure is:

  $\frac{\mathbf{d}\lambda(\mathbf{t})}{\mathbf{dt}} = \mathbf{a}(1-\lambda) - \mathbf{b}\lambda\dot{\gamma}^{\mathbf{m}}$;
- The equation of state (flow curve) is:

  $$\tau(\dot{\gamma},\mathbf{t}) = \tau_0 + (\eta_\infty + \mathbf{c}\lambda)\dot{\gamma}^{\mathbf{m}} \quad (1)$$

  $$\tau(\dot{\gamma},\mathbf{t}) = \tau_0 + (\eta_\infty + \mathbf{c}\lambda_{\mathbf{e}})\dot{\gamma} - \mathbf{c}\dot{\gamma}(\lambda_{\mathbf{e}} - \lambda_0)\mathbf{e}^{-(\mathbf{a}+\mathbf{b}\dot{\gamma}^{\mathbf{m}})\mathbf{t}} \quad (2)$$

where $\lambda_0$ gives the structure at time $\mathbf{t}_0 = 0$ and $\lambda_{\mathbf{e}} = \frac{1}{1+\frac{\mathbf{b}}{\mathbf{a}}\dot{\gamma}^{\mathbf{m}}}$ corresponds to the equilibrium structure. When equilibrium structure is achieved

$$\tau(\dot{\gamma},\mathbf{t}) = \tau_0 + (\eta_\infty + \mathbf{c}\lambda_{\mathbf{e}})\dot{\gamma} \quad (3)$$

## MATERIALS AND METHODS

Ketchup trade mark "Olineza" from Bulgarian market has been investigated.

The destroying and the recovery of the ketchup structure have been monitored by rotational viscometry HAAKE VT 550. Coaxial cylinder sensor SV-DIN has been used, which is recommended for high viscosity materials. The tests have been done at constant temperature 25°C. Two types of tests have been done to investigate the thixotropy and to calculate the parameters of the λ-model:

- *Multistep Steady State Test (MSST)*: This test is designed to determine the equilibrium flow curve. The test is produced over a shear rate range of 0.123 s-1 to 1000 $s^{-1}$. The maximum waiting time to reach equilibrium was 120 s. For each shear rate 5 repetitions have been done. The yield stress $\tau_0$, the infinite viscosity $\eta_\infty$, the viscosity increment **c**, the power law parameter **m** and the ratio **b/a** could be calculated from MSST test using equation (3).

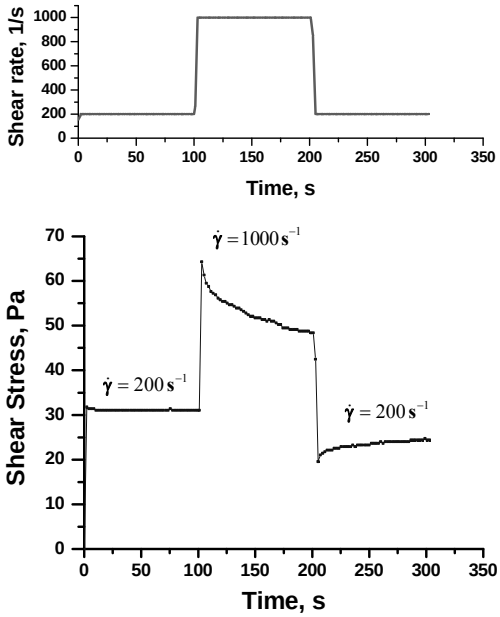
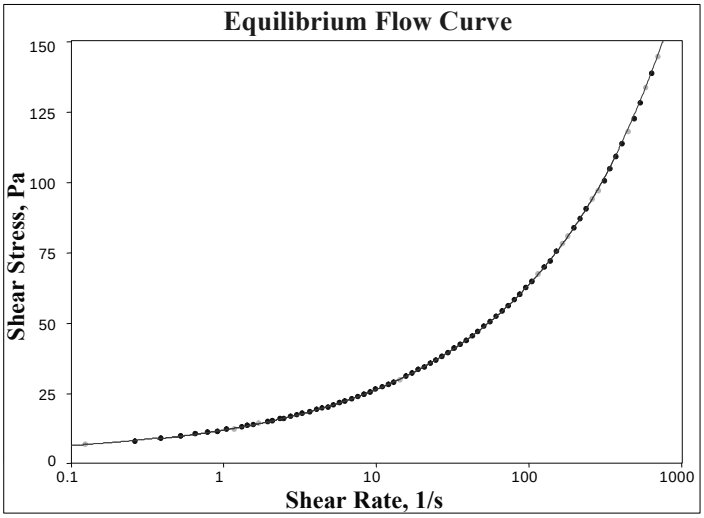



***Fig.1*** *Time test. Monitoring a build-up and break-down of ketchup structure at constant shear rate*

- *Time test*: The test consists of applying a constant shear rate and monitoring the viscosity and the shear stress as a function of time. This type of test, applied at several sections with different shear rates, is recommended for monitoring the thixotropic behaviour (fig. 1). The relaxation time $\tau_r$ and the separate values for **a** and **b** could be get from the time test.

RESULTS AND DISCUSSION

When the time tests at two different shear rate values are applied to the ketchup, its thixotropic behaviour could be demonstrated (fig. 1.) To analyze this thixotropic behaviour, a six parameter λ-model has been used (equation 2). The equilibrium flow curve has been successfully fitted to the model and 5 of the parameters have been determined (fig. 2). The values, received for the yield stress and the infinite viscosity are in good agreement with the data in the literature.




$$\tau(\dot{\gamma},t) = \tau_0 + (\eta_\infty + c\lambda_e)\dot{\gamma} - c\dot{\gamma}(\lambda_e - \lambda_0)e^{-(a+b\dot{\gamma}^m)t}$$

**Parameters:**
$\tau_0$=2.97 Pa
$\eta_\infty$=0.02 Pa.s
c=210.21 Pa.s
m=0.60
b/a=22.27 s

**Fig.2.** Multistep Steady State Test (MSST)

The λ-model propose just one relaxation time. The experimental curve from Time test could not be well fitted to the exponential model with one relaxation time (fig. 3.). The presence of spectrum of relaxation times makes the parameter calculations more difficult, because the distribution function is not known. Therefore a stretched exponential model has been suggested (Lindsey and Patterson, 1980). The relaxation spectrum is characterized by the parameter **β**, which values vary in the range **0<β<1**. As higher the β, the closer the spectrum distribution. Introducing the β parameter to the λ-model, the average (imaginary) relaxation time could be calculated from the dependence:

$$\tau(\dot{\gamma} = \mathbf{const}, t) = A(\dot{\gamma}) + B(\dot{\gamma}) e^{-\left[\left(a + b\dot{\gamma}^m\right)t\right]^{\beta}}, \tag{4}$$

where

$$A(\dot{\gamma}) = \tau_0 + \left( \eta_\infty + \frac{c}{1 + \frac{b}{a}\dot{\gamma}^m} \right) \dot{\gamma} = \mathbf{const} \text{ and } B(\dot{\gamma}) = c\dot{\gamma}(\lambda_e - \lambda_0) = \mathbf{const}.$$

The values of the model parameters are shown in fig. 4. The values of β-parameter practically do not depend on the shear rate and are the same for break-down and build-up state. They indicate relatively wide distribution of relaxation times.

The average relaxation time decreases with increasing the shear rate. It is one decay smaller in case of break-down state.

The a- and b-parameters increase when the shear rate increase. It could be interpreted as faster change in the structure.

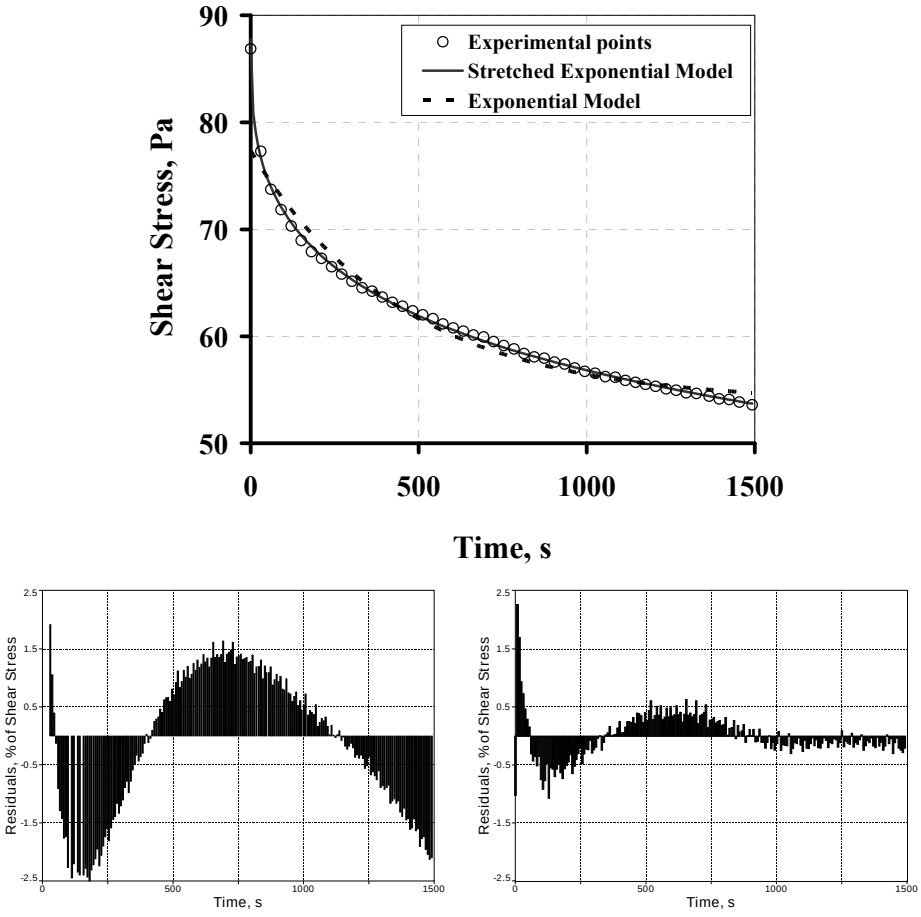



**Fig.3** Exponential and stretched exponential models for structure relaxation

CONCLUSIONS

- The λ-model well interprets the thixotropic behaviour of ketchup;
- A spectrum of relaxation times is observed during the relaxation of the ketchup structure. It could be analyzed by stretched exponential model by the β-parameter.
- The parameters in the λ-model indicate faster changes in the ketchup structure, when the shear rate increases.

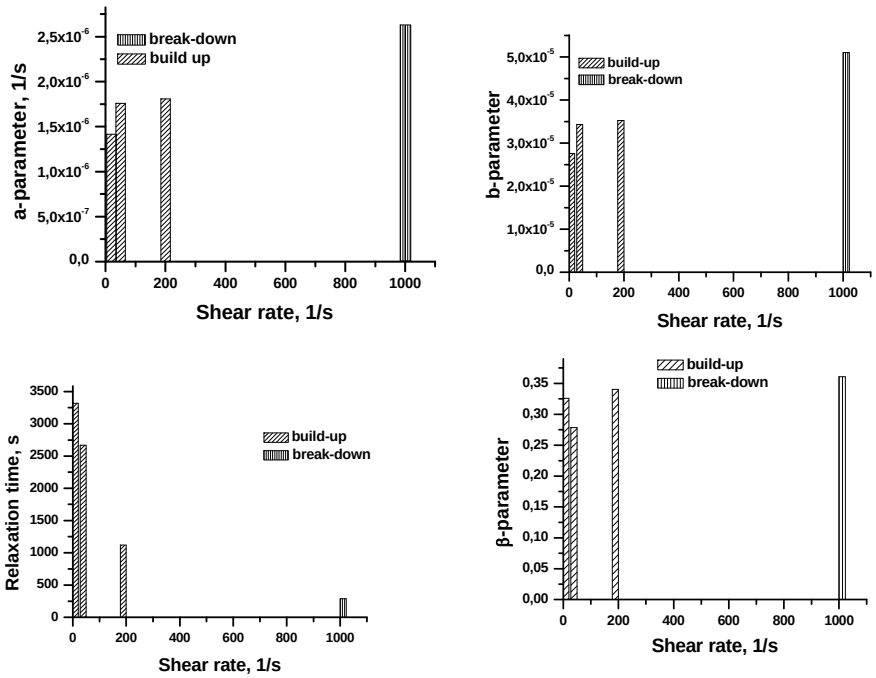



**Fig. 4** Effect of the shear rate on the model parameters

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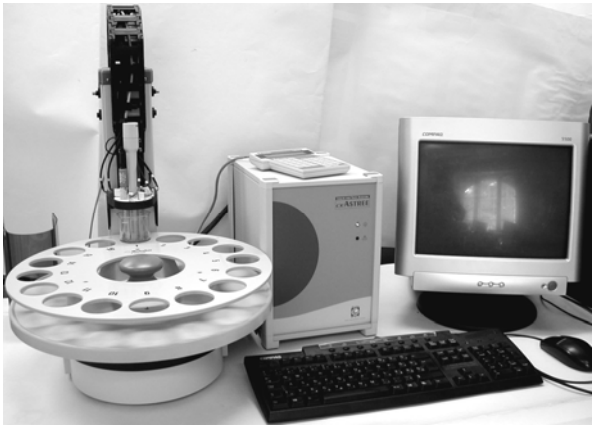
**TASTE MEASUREMENT BY MEANS OF THE A – ASTREE ELECTRONIC TONGUE**



The electronic tongue instrument is designed for analysis of taste and dissolved organic and inorganic compound chemicals that are typically found in liquids. The technology is a new (from 2000) and simple method to measure the liquid taste and flavor. The electronic tongue has seven liquid sensors (microchips covered by special membranes) and one Ag/AgCl reference electrode. The system measures the potential differences between the sensors and the Ag/AgCl electrode. Typically, e-tongue measures quantitative and qualitative taste attributes like saltiness, sweetness, bitterness, sourness and umami. Application areas include food and packaging, environment, perfumes and cosmetics, and the pharmaceutical industry.

The system allows reproducing sensory or analytical studies such as:

- Product or formulation matching
- Detection of taste-related defects
- Taste masking study
- Identification of sample origin
- Quantification of taste or target molecules
- Correlation with sensory descriptor intensity or classification
- Shelf- life study
- Comparison of an unknown sample to a "gold reference"

At this moment only one instrument is available in Hungary – at Corvinus University of Budapest, Faculty of Food Science, Department of Physics and Control.

# MICROWAVE DEHYDRATION IN THE INSTANT NOODLE

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## ABSTRACT

The paper deals with an interesting application of microwave technique: food technology. The experiment uses glutinous rice flour as major raw material, corn protein, salt and water as additional material, using palm oil as surface coating of base. The optional technical conditions are glutinous rice 50g, salt 2.4g, corn protein 5g, water content 50%, palm oil 1.5% (accounting for base weight). The microwave oven's power is 500W and heating duration 2 minutes. "Microwave instant noodle" is very fresh and mysterious to most consumers. The damage of the nutritive elements in noodle by microwave dehydration is much less than that of oil-fried product. So it is possible to produce many series of products that contain different raw materials and different compositions

## INTRODUCTION

Instant noodle, whose half-product is done in turn dough making press noodle, forming, steam noodle, etc, is very popular and convenient [1]. There are two methods to dehydrate the half-product, in which water content is about 30%. One is warm-air flow dehydration (heated-air drying) and the other is oil frying. The former has many disadvantages, for example, its mouth feeling and rehydration are bad. Its processing time and energy consumption are high. So, oil-frying dehydration is

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applied in most of Chinese instant noodle factories. When the oil content of instant noodle raises by 1%, the product cost will be increased at least 50,000 RMB annually in a medium production assemble. At the same time the high oil content would worse the rehydration process. In addition, the appearance of the noodle may have a bad effect on the consumers and the yellow color of the fried product will bring a bad appetite [2].

If the microwave technology is applied into the instant noodle dehydration, the problems above could be resolved. The oil content of the product will be greatly decreased while its rehydration and whiteness will be both raised. To top off it, the quality of the production can also be controlled safely [3], [4].

It can be remarked that the work conditions in the microwaves heating processes are better than in the traditional heating processes[5], [6]. There is neither dust or smoke, nor external heating. The power efficiency is larger and the quality of products is better. [7].

However, the cost of the caloric unit is larger than in the case of the traditional heating processes. The aim of this paper is to present the study of the microwave dehydration in the instant noodle

## MATERIALS AND METHODS

### *2.1 Main raw materials*

Common products: flour, edible palm fat, food additive.

### *2,2 Main equipments & instruments*

Instant noodle production assemble line; microwave oven; blast dry oven; whiteness instrument; Saxhet's extractor; tension meter.

### *2.3 Experimental methods*

The half-product is produced by traditional technique. The half-product in glass container is dried in microwave oven.

The water content of product before dehydration and after dehydration are measured at GB. The water content before dehydration is about 30% while the one after should be below 5%. In order to imitate warm-air flow drying product, the half-product is dried by heated-air in blast dry oven at $110\pm5^{0}$C simultaneously.

*2.4 Analysis methods*

Water content: China Bureau of Standard (GB) 5009.3-85;
Oil content: China Bureau of Standard (GB) 5009.3-85;
Rehydration time: China Bureau of Standard (GB) 9848-88;
Whiteness: whiteness instrument.

## RESULTS AND DISCUSSION

The experimental results of product dehydration.

The water contents of product and the dehydration time in the different ways are shown in Fig. 1.

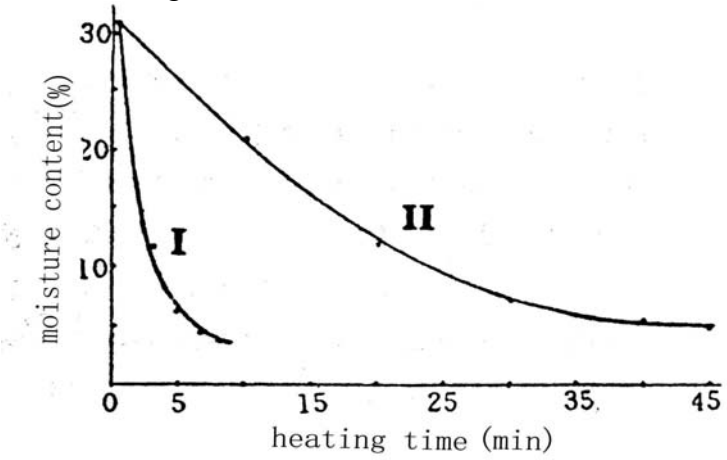


Figure 1 Moisture content with heating time curve:
I. Microwave, II. Heated-air drying

The oil content, rehydration time and whiteness are shown in table 1.

Table 1. Results of oil content, rehydration time and whiteness test

| | Oil frying | Microwave | Heated-air |
|---|---|---|---|
| Oil content (%) | 22.4 | 1.9 | 1.9 |
| Rehydration (s) | 300 | 230 | 400 |
| Whiteness | 55.4 | 59.6 | 58.9 |

The information above shows that the water content can be reduced to 5% within 8 minutes by microwave technology while the drying time is even shorter than that of one-fifth of warm-air flow dried product.

The oil content of microwave noodle is a little higher than that of raw flour oil (1.6%). The reason is that the half-product absorbs the oil on the product line.

The microwave noodle exposes to nature environment at $23^0$C, 34% humidity for 2 hours is weighed (fig. 2). The results show that the product is completely dried and its rehydration is better. The microwave noodle absorbs water violently when put in boiling water and, at the same time, a great amount of gas is puffed. The noodle will be completely rehydrated within 300 seconds if the temperature is beyond $68^0$C.

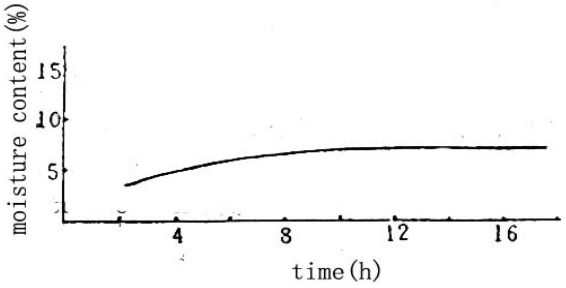


Figure 2 Microwave instant noodle hydroscopicity curve

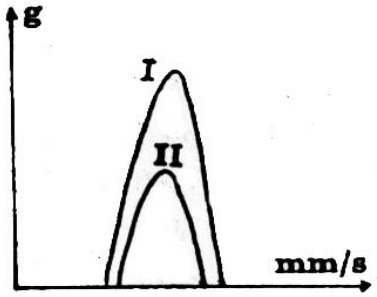


Figure 3 Tensile test curve I: microwave II: oil fried

The tendon strength of the rehydrated microwave-noodle (40min) is also measured by tension meter. The results are showed in Fig. 3. The taste panel on the spot also proves that the microwave noodle is more elastic than the oil fried product.

## CONCLUSIONS AND PROSPECTS

1. The information above shows that it is completely feasible to apply microwave technology in the instant noodle dehydration.
2. The damage of the nutritive elements in noodle by microwave dehydration is much less than that of oil-fried product. So it is possible to produce many series of products that contain different raw materials and different compositions.
3. Microwave dehydration will avoid oil smoke, nutrition damage and other harmful materials that may be produced during the oil frying. The oil content can also be controlled precisely by the ingredient and the oil content in the soup blending. This will help the noodle industry to a constructive developing.
4. The people including technicians, managers etc. involved in the microwave dehydration technology must be skillful and have enough knowledge. It is good for the promotion of the food industry.
5. As for microwave dehydration, water absorbs microwave energy efficiently at 915MHz and 2450MHz [7]. The efficiency is beyond 70%, it is very prospective to apply this technology both in the home and the aboard.
6. "Microwave instant noodle" is very fresh and mysterious to most consumers. It is also an opportunity to develop instant noodle marketing.

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