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## CONTENT

### THE CONTENT, COMPOSITION AND ANTIOXIDANT ACTIVITY OF PHENOLIC COMPOUNDS OF DIFFERENT AQUEOUS EXTRACTS OF NETTLE (*URTICA DIOICA* L.) SEEDS

*Jelena Mitrović, Nada Nikolić, Ivana Karabegović, Miodrag Lazić* 1

### CANNABINOIDS CONTENT AND FATTY ACIDS COMPOSITION IN TWELVE EUROPEAN FIBER HEMP VARIETIES

*Tijana Zeremski, Nadežda Stojanov, Biljana Kiprovska, Vladimir Sikora, Jegor Miladinović, Anamarija Koren, Stanko Milić* 6

### POSSIBILITY OF FIBER HEMP ESSENTIAL OIL UTILIZATION AS AN AROMA AND FRAGRANCE ADDITIVE

*Nadežda Stojanov, Tijana Zeremski, Biljana Kiprovska, Anamarija Koren, Vladimir Sikora, Jegor Miladinović, Milica Aćimović* 12

### MATERNAL FOOD SUPPLEMENTS USE DURING PREGNANCY

*Suzana Miljković* 18

### SELENIUM BIOFORTIFICATION OF PAK CHOI: SOIL VS. FOLIAR NUTRITION

*Juan J. Rios, Micaela Carvajal, Diego A. Moreno* 24

### ELICITATION OF BRASSICAS FOR INCREASING BIOACTIVE COMPOUNDS

*Paula Garcia-Ibañez, Lucia Yepes, Diego A. Moreno, Micaela Carvajal* 29

### NANOENCAPSULATED GLUCOCOSINOLATES FOR NUTRACEUTICAL APPLICATIONS

*Lucía Yepes, Diego A. Moreno, Raúl Domínguez-Perles, M. Carmen Martínez-Ballesta, Micaela Carvajal* 34

### CHARACTERISTICS OF CHICKEN COOKED SAUSAGES WITH A FAT CONTENT REDUCTION

*Djordje Okanović, Joksimović Milica, Slobodan Lilić, Dragica Karan, Vladimir Korišanac* 40

### FORTIFIED PASTA WITH PLANT BASED INGREDIENTS – INFLUENCE ON MICROBIOLOGICAL QUALITY

*Meta Sterniša, Marija Borljin, Sonja Smole Možina, Peter Raspor, Dragana Šoronja-Simović, Zita Šereš, Jana Zahorec* 46

### THE EFFECT OF WHEY PROTEIN CONCENTRATE ON ENCAPSULATION EFFICIENCY AND VIABILITY OF PROBIOTIC STARTER CULTURE IN NATURAL BIOPOLYMER CARRIERS

*Nataša Obradović, Tanja Krunić, Mina Volić, Ivana Pajić-Lijaković, Viktor Nedović, Marica Rakin, Branko Bugarski* 51

### ENCAPSULATION OF THYME ESSENTIAL OIL IN ALGINATE-CASEIN BEADS FOR INTESTINAL DELIVERY

*Mina Volić, Nataša Obradović, Verica Djordjević, Zorica Knežević-Jugović, Ilinka Pećinar, Zora Stevanović-Dajić, Branko Bugarski* 57

### EFFECTS OF APPLICATION OF COLORED SHADE NETS IN TOMATO GROWING ON BIOACTIVE COMPOUNDS CONTENT IN TOMATO FRUITS

*Aleksandar Gledić, Aleksandra Jakšić, Renata Kovač, Lidija Milenković, Jasna Mastilović, Žarko Kevrešan, Zoran Ilić* 63

### THE INFLUENCE OF ADDING OF FLAXSEED OIL TO SUNFLOWER OIL ON THE CONTENT OF TOCOPHEROLS AND CAROTENOIDS IN BLENDED EDIBLE OILS

*Tanja Lužaić, Ranko Romanić, Bojana Radić, Nada Grahovac, Snežana Kravić, Zorica Stojanović* 68

### AN INSIGHT INTO QUALITY OF APRICOT AND SWEET CHERRY FRUIT WINES

*Uroš Čakar, Aleksandar Petrović, Boris Pejcin, Nikolina Lisov, Marijana Živković, Vlatka Vajs, Brižita Đorđević* 74

### TRANSGLUTAMINASE INFLUENCE ON PHYSICO-CHEMICAL AND RHEOLOGICAL CHARACTERISTICS OF FERMENTED DAIRY BEVERAGES PRODUCED BY MICROFILTRATED KOMBUCHA INOCULUM

*Mirela Iličić, Spasenija Milanović, Marijana Carić, Katarina Kanurić, Vladimir Vukić, Dajana Vukić* 80

### THE EFFECT OF FLAVOURINGS ON QUALITY OF FRESH CHEESE

*Mirela Iličić, Katarina Kanurić, Vladimir Vukić, Dajana Vukić, Maja Bjekić, Marija Bukarac* 86

### HOME-MADE BREAD SUPPLEMENTED WITH DEBETAINIZED MOLASSES: QUALITY ATTRIBUTES AND NUTRITIONAL CONTENT

*Bojana Filipčev, Rada Jevtić Mučibabić, Olivera Šimurina* 92

<b>THE COMBINED EFFECT OF BEETROOT JUICE AND WHOLEGRAIN FLOURS TO IMPROVE HEALTH PROMOTING PROPERTIES OF COOKIES</b> <i>Jelena Čakarević, Aleksandra Torbica, Jelena Tomić, Miona Belović, Vanja Šeregelj, Vesna Tumbas Šaponjac, Jelena Vulić and Ljiljana Popović</i>	<b>98</b>
<b>EXTRACTION OF DIFFERENT GARLIC VARIETIES (<i>ALLIUM SATIVUM</i> L.) – DETERMINATION OF ORGANOSULFUR COMPOUNDS AND MICROBIOLOGICAL ACTIVITY</b> <i>Jelena Bajac, Branislava Nikolovski, Sunčica Kocić-Tanackov, Alena Tomšik, Anamarija Mandić, Jelica Gvozdanović-Varga, Slobodan Vlajić, Milena Vujanović, Marija Radojković</i>	<b>104</b>
<b>ANTIOXIDANT AND ANTIMICROBIAL ACTIVITY OF MUSHROOMS <i>DAEDALEA QUERCINA</i> AND <i>FISTULINA HEPATICA</i></b> <i>Tijana Dubljanin, Milica Petrović, Maja Kozarski, Miomir Nikšić, Anita Klaus, Jovana Vunduk</i>	<b>110</b>
<b>PHENOLICS AND ANTIOXIDANT POTENTIAL OF AGED SOUR CHERRY LIQUEURS</b> <i>Bozidar Ristovski, Nevenka Macukova, Mirjana Bocevska</i>	<b>116</b>
<b>IMPACT OF EXTRUSION PROCESSING PARAMETERS ON FUNCTIONAL PROPERTIES OF SNACK PRODUCTS FROM SPELT WHOLEGRAIN FLOUR WITH ADDED BETAINE</b> <i>Jovana Kojić, Nemanja Teslić, Nebojša Ilić, Bojana Kokić, Jelena Krulj, Bojana Filipčev, Marija Bodroža Solarov</i>	<b>123</b>
<b>UTILISATION OF BLUE WHITING BY-PRODUCTS GENERATED DURING SURIMI PROCESSING: BIOACTIVITIES OF FISH GELATINE HYDROLYSATES</b> <i>Ivan Milovanovic, Maria Hayes</i>	<b>129</b>
<b>HYDRODYNAMIC FLOW REGIMES IDENTIFICATION IN AIRLIFT BIOREACTORS BASED ON MACHINE LEARNING CLASSIFICATION</b> <i>Predrag Kojić, Nataša Lukić, Svetlana Popović</i>	<b>134</b>
<b>THE INFLUENCE OF SOLVENT CONCENTRATIONS AND COLUMN TEMPERATURES ON THE SEPARATION OF GLIADIN PROTEINS EFFECTIVENESS BY RP-HPLC</b> <i>Vesna Gojković, Radoslav Grujić, Željka Marjanović-Balaban, Aleksandra Torbica</i>	<b>139</b>
<b>FLOW REGIMES CLASSIFICATION IN AIRLIFT BIOREACTORS WITH A SHALLOW NEURAL NETWORK</b> <i>Predrag Kojić, Nataša Lukić, Svetlana Popović</i>	<b>146</b>
<b>OSMOTIC DEHYDRATION OF CABBAGE IN SUGAR BEET MOLASSES-SHELF LIFE STUDY</b> <i>Biljana Cvetković, Lato Pezo, Ljubiša Šarić, Jasmina Lazarević, Dragana Plavšić, Bojana Filipčev, Danijela Šuput</i>	<b>150</b>
<b>ANTIBACTERIAL ACTIVITY AND CHEMICAL COMPOSITION OF DOMESTIC HONEY</b> <i>Vesna Kalaba, Biljana Pećanac, Bojan Golić, Dragana Kalaba</i>	<b>157</b>
<b>INFLUENCE OF STATIC MIXER ON STREPTOMYCETES MICROFILTRATION</b> <i>Ivana Pajčin, Nemanja Milović, Aleksandar Jokić, Ivana Mitrović, Jelena Dodić, Jovana Grahovac, Nataša Lukić</i>	<b>165</b>
<b>PHYTOREMEDIATION - AN ECOLOGICAL APPROACH FOR SAFETY FOOD PRODUCTION</b> <i>Irena Bogoeva</i>	<b>171</b>
<b>CHANGES OF DOUGH AND BREAD PERFORMANCE OF POOR QUALITY WHEAT AS A RESULT OF RYE AND OAT FLOURS ADDITION</b> <i>Aleksandra Torbica, Jelena Tomić, Miona Belović</i>	<b>176</b>
<b>VERIABILITY OF QUALITY PARAMETERS OF THE MILL FLOUR STREAMS AS A BASE FOR OPTIMISATION OF COMPOSITE FLOURS END USE PURPOSES</b> <i>Vanja Balaban, Milan Vukić, Marko Ivanović, Jasna Mastilović, Žarko Kevrešan</i>	<b>182</b>
<b>OSMOTIC TREATMENT IMPACT ON THE COLOUR CHANGES OF CELERY LEAVES</b> <i>Milica Nićetin, Lato Pezo, Vladimir Filipović, Biljana Lončar, Violeta Knežević, Jelena Filipović, Tatjana Kuljanin</i>	<b>187</b>
<b>RETROGRADATION KINETICS OF WHEAT STARCH - OSA MODIFIED WAXY MAIZE STARCH MIXTURES</b> <i>Miroslav Hadnađev, Tamara Dapčević-Hadnađev, Milica Pojić, Nataša Milićević, Aleksandra Torbica</i>	<b>193</b>
<b>OPTIMIZATION OF THE WHEAT STARCH SUSPENSIONS MICROFILTRATION PROCESS USING TWISTED TAPE AS TURBULENCE PROMOTER</b> <i>Bojana Ikonić, Jelena Pavličević, Oskar Bera, Aleksandar Jokić, Predrag Ikonić, Predrag Kojić, Milica Pojić</i>	<b>199</b>

<b>WHEY VALORIZATION USING TRANSGALACTOSYLATION ACTIVITY OF <math>\beta</math>-GALACTOSIDASE</b>	
<i>Ana Milivojević, Milica Carević, Marija Ćorović, Katarina Banjanac, Dejan Bezbradica</i>	206
<b>A COMPARATIVE STUDY ON THE EFFECTS OF BENTONITE AND SUGAR BEET PULP APPLICATION IN MOLASSES PURIFICATION TREATMENT</b>	
<i>Miljana Djordjević, Szabolcs Kertész, Zita Šereš, Nikola Maravić, Cecília Hodúr, Dragana Šoronja-Simović, Marijana Djordjević</i>	212
<b>THE EFFECT OF BREWER'S SPENT GRAIN ADDITION ON PHYSICO-CHEMICAL PROPERTIES OF EXTRUDED MEAT SNACKS</b>	
<i>Jovana Delić, Predrag Ikonić, Radmilo Čolović, Tatjana Peulić, Vojislav Banjac, Slađana Rakita, Marija Jokanović</i>	218
<b>APPLE FIBRE AND HYDROXYPROPYLMETHYLCELLULOSE IN GLUTEN-FREE FORMULATIONS: FUNDAMENTAL RHEOLOGICAL APPROACH</b>	
<i>Marijana Djordjević, Dragana Šoronja-Simović, Ivana Nikolić, Miljana Djordjević, Zita Šereš, Ljubica Dokić, Nikola Maravić</i>	224
<b>FILTRATION OF SUNFLOWER OIL TO REMOVE WAXES ASSISTED BY FILTRATION AIDS: AN INDUSTRIAL STUDY</b>	
<i>Branislava Nikolovski, Katarina Nedić Grujin, Ranko Romanić</i>	230
<b>EXAMINATION OF MILLING PROPERTIES OF DIFFERENT WHEAT VARIETIES</b>	
<i>Antal Véha, Zoltán Magyar, Balázs P. Szabó</i>	236
<b>EFFECTS OF WATER SUBSTITUTION WITH FRESH LIQUID WHEY IN BREAD PRODUCTION</b>	
<i>Ivana Cvetojević, Milan Vukić, Marko Ivanović, Jasna Mastilović, Žarko Kevrešan</i>	242
<b>PRODUCTION OF SUNFLOWER MEAL PROTEIN HYDROLYSATE BY SEQUENTIAL HYDROLYSIS WITH ALCALASE AND FLAVOURZYME IMMOBILIZED ON FUNCTIONALIZED SILICA NANOPARTICLES</b>	
<i>Katarina Banjanac, Ana Milivojević, Marija Ćorović, Milica Carević, Nevena Prlainović, Aleksandar Marinković, Dejan Bezbradica</i>	247
<b>INFLUENCE OF FILTRATION AIDS BASED ON CELLULOSE ON PHOSPHOLIPIDS AND SOAPS CONTENT IN SUNFLOWER OIL AFTER WINTERIZATION</b>	
<i>Ranko Romanić, Katarina Nedić Grujin, Branislava Nikolovski, Marija Gvozdenović</i>	253
<b>INFLUENCE OF DIFFERENT DISTILLATES AND EXTRACTION TIMES OF FUNGUS <i>Ganoderma lucidum</i> ON THE ANTIOXIDANT POTENTIAL AND SENSORY CHARACTERISTICS OF SPECIAL HERB BRANDIES</b>	
<i>Sonja Veljović, Saša Despotović, Mile Veljović, Marija Petrović, Predrag Vukosavljević, Ninoslav Nikićević, Miomir Nikšić</i>	259
<b>PREVALENCE, CHARACTERIZATION AND ANTIMICROBIAL RESISTANCE OF <i>Salmonella enterica</i> FROM PIG SLAUGHTERHOUSES IN BELGRADE</b>	
<i>Jasna Kureljušić, Nemanja Zdravković, Jadranka Žutić, Vesna Milićević, Aleksandra Tasić, Branislav Kureljušić, Ivan Vičić, Neđeljko Karabasil</i>	265
<b>DEVELOPMENT AND VALIDATION OF MODIFIED QuEChERS METHODS FOR THE ANALYSIS FIPRONIL AND ITS METABOLITES IN EGG PRODUCTS</b>	
<i>Aleksandra Tasić, Tijana Mitrović, Jasna Kureljušić, Dobrila Jakić - Dimić, Nebojša Vuković</i>	269
<b>ANTIMICROBIAL AND ANTIADHESION EFFECT OF SECONDARY PLANT METABOLITES AGAINST SPOILAGE BACTERIA <i>Pseudomonas</i> AND <i>Shewanella</i></b>	
<i>Meta Sterniša, Chiara Purgatorio, Antonello Paparella, Sonja Smole Možina</i>	274
<b>DO FOOD RECALLS HAVE A GREATER EFFECT ON CONSUMERS' CONFIDENCE WHEN THEY INVOLVE HEALTHY, ORGANIC AND PROTECTED DESIGNATION OF ORIGIN PRODUCTS AND, IF YES, WHY?</b>	
<i>Paola Cane</i>	280
<b>PERSISTENCE AND DISSIPATION DYNAMIC OF CYANTRANILIPROLE IN TOMATO</b>	
<i>Sanja Lazić, Dragana Šunjka, Slavica Vuković, Antonije Žunić, Agneša Szarka, Vladimir Višacki, Svetlana Hrouzková</i>	292
<b>THE EMPHASIS OF <i>Listeria monocytogenes</i> IN RAW MEAT</b>	
<i>Suzana Vidaković, Jelena Babić, Slobodan Knežević, Neđeljko Karabasil, Mirjana Dimitrijević, Dubravka Milanov</i>	296
<b>INFLUENCE OF COMMON COOKING METHODS ON GLUCOSINOLATES AND ISOTHIOCYANATES CONTENT IN NOVEL BRASSICA VEGETABLES</b>	
<i>Nieves Baenas, Débora Villaño, Javier Marhuenda, Cristina García-Viguera, Pilar Zafrilla, Diego A. Moreno</i>	300



<b>POTENTIAL OF COMMERCIAL ESSENTIAL OILS MIXTURE TO PREVENT INFECTIONS OF ORANGE FRUITS BY <i>Penicillium expansum</i></b>	
<i>Ivana Čabarkapa, Irena Rakić, Nevena Blago, Zorica Tomičić, Ružica Tomičić</i>	<b>305</b>
<b>ELECTROCHEMICAL DETERMINATION OF SELECTED PESTICIDES IN ENVIRONMENTAL WATER SAMPLES</b>	
<i>Zorica Stojanović, Ana Đurović, Snežana Kravić, Nada Grahovac</i>	<b>310</b>
<b>GENETIC VARIABILITY OF A DANDELION (<i>Taraxacum officinale</i> Web.) POPULATIONS AND NUTRITIONAL COMPOSITION OF DIFFERENT PLANT PARTS</b>	
<i>Lovro Sinkovič, Barbara Pipan, Vladimir Meglič</i>	<b>315</b>
<b>COMPARISON OF THE CYCLIC VOLTAMMETRY (CV) MEASUREMENT AND DPPH• SPECTROPHOTOMETRIC ASSAY FOR THE DETERMINATION OF ANTIOXIDANT CAPACITY OF COMMERCIAL OENOLOGICAL TANNINS</b>	
<i>Arianna Ricci, Giuseppina P. Parpinello, Nemanja Teslić, Paul A. Kilmartin, Andrea Versari</i>	<b>321</b>
<b>MINERAL CONTENT AND COLOUR OF HONEY FROM AUTONOMOUS PROVINCE OF VOJVODINA</b>	
<i>Aleksandar Marić, Pavle Jovanov, Marijana Sakač, Anamarija Mandić, Nataša Miličević, Jovana Kos, Aleksandra Novaković</i>	<b>328</b>
<b>ARSENIC QUANTITY IN FRESH AND FROZEN SEA FOOD FOUND IN BOSNIAN AND HERZEGOVINIAN MARKET</b>	
<i>Biljana Pećanac, Jelena Aničić, Milijana Golić, Radovan Jeftenić, Željko Sladojević</i>	<b>333</b>
<b>APPLICATION OF CHITOSAN COATINGS IN QUALITY CONTROL OF STRAWBERRIES</b>	
<i>Gordana Jovanović, Aleksandra Krsmanović</i>	<b>339</b>
<b>HEPATITIS E VIRUS - A NOVEL FOODBORNE PATHOGEN</b>	
<i>Branko Velebit, Lazar Milojević, Vesna Đorđević</i>	<b>345</b>
<b>EFFECTS OF CAROB FLOUR AND SUGAR BEET FIBERS ADDITION ON QUALITY OF GINGERBREAD TYPE BISCUITS</b>	
<i>Olivera Šimurina, Jana Zahorec, Meta Sterniša, Sonja Smole Možina, Nikola Maravić, Zita Šereš, Dragana Šoronja-Simović, Bojana Filipčev</i>	<b>350</b>
<b>THE EFFECT OF THE ADDITION OF A FUNCTIONAL ALGINATE-BASED COMPOUND ON THE SENSORY PROPERTIES, TEXTURE AND COLOUR OF THE HOT DOGS</b>	
<i>Vladimir Kurćubić, Natalija Džinić, Marija Jokanović, Maja Ivić, Branislav Šojić, Nataša Radić, Snežana Škaljac</i>	<b>356</b>
<b>WHEAT QUALITY UNDER THE CONDITIONS OF GLOBAL CLIMATE CHANGES</b>	
<i>Sonja Ilin, Bojan Jocković, Beba Mutavdžić, Dušica Čolović, Radivoje Jevtić, Dragan Živančev, Novica Mladenov</i>	<b>363</b>
<b>DETERMINATION OF TOCOPHEROL CONTENT IN VEGETABLE OILS AS QUALITY PARAMETER</b>	
<i>Milica Basic, Zorica Basic, Brizita Djordjevic</i>	<b>368</b>
<b>GENOTYPIC VARIATION OF FATTY ACID COMPOSITION IN SAFFLOWER (<i>Carthamus tinctorius</i> L.) OIL</b>	
<i>Ana Marjanović Jeromela, Nada Grahovac, Zvonko Sakač, Snežana Kravić, Zorica Stojanović, Ana Đurović, Ankica Kondić Špika, Dragana Miladinović</i>	<b>372</b>
<b>EFFECT OF GROWING SEASON ON QUALITY PARAMETERS OF OLD AND NEW WHEAT (<i>Triticum aestivum</i> L.) VARIETIES</b>	
<i>Ankica Kondić Špika, Novica Mladenov, Dragan Živančev, Sanja Mikić, Dragana Trkulja, Nada Grahovac, Ana Marjanović Jeromela</i>	<b>377</b>
<b>INFLUENCE OF VACUUM PACKAGING ON SENSORY AND LIPID STABILITY OF PRECOOKED PORK CHOPS</b>	
<i>Marija Jokanović, Maja Ivić, Branislav Šojić, Snežana Škaljac, Vladimir Tomović, Tatjana Peulić, Predrag Ikonić, Natalija Džinić</i>	<b>383</b>
<b>NUTRITIONAL COMPOSITION OF COMMON BEAN (<i>Phaseolus vulgaris</i> L.) AS GREEN BEANS AND GRAINS</b>	
<i>Lovro Sinkovič, Barbara Pipan, Aleksandra Tepić Horecki, Filip Šibul, Vladimir Meglič</i>	<b>388</b>
<b>ROLE OF CERTIFICATION MARKS IN ENHANCING COMPETITIVENESS</b>	
<i>Nataša Vukelić, Nebojša Novković, Selena Rokvić</i>	<b>394</b>
<b>MORPHOLOGICAL AND MOLECULAR CHARACTERIZATION OF <i>Aspergillus flavus</i> ISOLATES FROM COMMON WHEAT AND SPELT GRAINS COLLECTED IN NORTH SERBIA</b>	
<i>Jelena Krulj, Nataša Čurčić, Aleksandra Bočarov Stančić, Jovana Kojić, Jelena Perović, Boško Marić, Marija Bodroža Solarov</i>	<b>399</b>

<b>TOCOPHEROL CONTENT IN COLD-PRESSED OIL FROM DIFFERENT SUNFLOWER HYBRIDS GROWN IN SERBIA</b> <i>Nada Grahovac, Zvonimir Sakač, Snežana Kravić, Zorica Stojanović, Ranko Romanić, Tanja Lužaić, Sandra Cvejić, Siniša Jocić, Ana Marjanović-Jeromela</i>	<b>404</b>
<b>EFFICACY OF WHEAT CLEANING ON DEOXYNIVALENOL CONTENT OF FOUR WHEAT VARIETIES PRODUCED CONVENTIONALLY AND ORGANICALLY</b> <i>Aleš Kolmanič</i>	<b>408</b>
<b>INFLUENCE OF CONSUMERS' EXPECTATIONS ON THE SENSORY ACCEPTANCE OF TRADITIONAL MEAT PRODUCTS</b> <i>Milan Ristić, Klaus Troeger, Jasna Djinović-Stojanović, Nemanja Knezević, Ivan Vukasović</i>	<b>414</b>
<b>FRUIT TRAITS, CAPSAICIN AND DIHYDROCAPSAICIN CONTENT IN SOME SERBIAN HOT PEPPERS</b> <i>Dario Danojević, Tijana Zeremski, Nadežda Stojanov, Slađana Medić-Pap, Jelica Gvozdanović-Varga, Janko Červenski</i>	<b>420</b>
<b>INFLUENCE OF SURFACTANT TWEEN 20 ON ANTIOXIDANT ACTIVITY OF ACTIVE BIOPOLYMER FILMS</b> <i>Sandra Bulut, Vera Lazić, Senka Popović, Nevena Hromiš, Danijela Šuput, Radomir Malbaša, Jasmina Vitas</i>	<b>427</b>
<b>PIGMENT AND POLYPHENOL CONTENTS AND LEAF STOMATA CHANGES DURING SHELF LIFE OF LETTUCE STORED AT LOW TEMPERATURE</b> <i>Renata Kovač, Aleksandra Bajić, Dragana Ubiparip Samek, Aleksandar Gledić, Žarko Kevrešan, Jasna Mastilović</i>	<b>433</b>
<b>SORTING OF RIGID PACKAGING PLASTIC WASTE: A CASE STUDY IN NORWAY</b> <i>Tanja Radusin, Jorunn Nilsen, Marit Kvalvåg Pettersen, Siw Bodil Fredriksen</i>	<b>439</b>
<b>CORRESPONDENCE ANALYSIS OF FRUIT CONSUMPTION IN VOJVODINA</b> <i>Dragana Ubiparip Samek, Lato Pezo, Jasna Mastilović, Žarko Kevrešan, Renata Kovač, Tihomir Zoranović, Branislav Vlahović</i>	<b>444</b>
<b>POTENTIAL RISKS AND OPPORTUNITIES IN USE OF RECYCLED POLYOLEFINS OBTAINED FROM POST-CONSUMER WASTE IN NORWAY</b> <i>Tanja Radusin, Jorunn Nilsen, Marianne Sørflaten Eikeland, Marit Kvalvåg Pettersen, Siw Bodil Fredriksen</i>	<b>450</b>
<b>EFFECT OF PLASTICIZER AND pH VALUES ON PROPERTIES OF SUNFLOWER OIL CAKE BIODEGRADABLE FILMS</b> <i>Danijela Šuput, Senka Popović, Nevena Hromiš, Sandra Bulut, Lato Pezo, Vera Lazić</i>	<b>457</b>
<b>INFLUENCE OF POLYETHYLENE PACKAGING ON QUALITY PRESERVATION AND BIOACTIVE COMPOUNDS CONTENT IN GARLIC</b> <i>Aleksandra Bajić, Alena Tomšik, Jasna Mastilović, Žarko Kevrešan, Aleksandar Gledić, Jelica Gvozdenović Varga</i>	<b>463</b>
<b>TEXTURE AND APPEARANCE OF INDUSTRIALLY PRODUCED COW'S BEATEN CHEESE</b> <i>Irena Karova, Jana Simonovska, Elena Velickova, Eleonora Winkelhausen, Mishela Temkov, Vesna Rafajlovska</i>	<b>469</b>
<b>CONTRIBUTION OF COLD PRESSED OILS ON SENSORY PROPERTIES OF MAYONNAISE</b> <i>Biljana Rabrenović, Dragana Paunović, Etelka Dimić, Natalija Džinić, Mirjana Demin, Jelena Popović-Đorđević</i>	<b>474</b>
<b>CHANGES OF PHYSICAL CHARACTERISTICS OF SJENIČKI SUDŽUK DURING PRODUCTION IN TRADITIONAL CONDITIONS</b> <i>Nedim Čučević, Marija Jakanović, Predrag Ikonić, Snežana Škaljac, Maja Ivić, Branislav Šojić, Tatjana Peulić, Vladimir Tomović</i>	<b>480</b>
<b>FACTORS AFFECTING THE SHELF LIFE OF FRESH FISH</b> <i>Dragana Ljubojević Pelić, Jelena Babić, Suzana Vidaković, Miloš Pelić, Milica Živkov Baloš, Dubravka Milanov, Nikolina Novakov, Vladimir Radosavljević, Miroslav Ćirković</i>	<b>486</b>

## EFFECT OF GROWING SEASON ON QUALITY PARAMETERS OF OLD AND NEW WHEAT (*Triticum aestivum* L.) VARIETIES

Ankica Kondić Špika, Novica Mladenov, Dragan Živančev, Sanja Mikić, Dragana Trkulja, Nada Grahovac, Ana Marjanović Jeromela

Institute of Field and Vegetable Crops, Maksima Gorkog 30, 21000 Novi Sad, Serbia

\*Corresponding author:

E-mail address: [ankica.spika@ifvcns.ns.ac.rs](mailto:ankica.spika@ifvcns.ns.ac.rs)

### ABSTRACT

The objective of this study was to analyse genotypic variations of some important wheat quality parameters (protein content – PC, sedimentation value – SD, wet gluten content – WG and dry gluten content – DG) during two growing seasons (2010 and 2011). The trial was conducted at the experimental field of the Institute of Field and Vegetable Crops, Novi Sad, with 25 wheat varieties registered and cultivated in Serbia for the last 60 years. PC, SD and WG were determined by Kjeldahl method, Zeleny sedimentation test and manual method, respectively. Strong year and genotype effects were found for all the quality traits of the studied varieties, while the effect of their interaction was not significant. The protein content of the wheat varieties ranged between 11.2% - 17.8%, with wet and dry gluten contents of 21.2 – 47.9% and 7 – 16%, respectively. Sedimentation value varied from 14 (cv. San Pastore) to 58 ml (cv. Pesma). Total protein content was positively correlated with the wet and dry gluten contents. Also, the correlation analyses have shown that older wheat varieties had higher protein content, as well as wet and dry gluten contents, but lower sedimentation values than modern cultivars. However, it should be noted that significant genotypic variations were found for all the analysed traits and varieties with good quality parameters could be identified among old and new cultivars.

**Keywords:** *protein content, sedimentation value, wet and dry gluten contents, wheat varieties*

### INTRODUCTION

A complex mixture of proteins present in wheat grains possesses the unique ability to form viscoelastic dough when flour is mixed with water (Delcour et al., 2010). The protein quantity and quality are essential for bread making potential of wheat genotypes (Hruskova and Famera, 2003). The flour with specific quality characteristics including protein content, wet and dry gluten and rheological properties is required for baking industry (Miralbes, 2004).

Gluten, the protein component of flour plays a key role in determining the baking quality of wheat by influencing water absorption capacity, cohesiveness, viscosity and elasticity of dough (Wieser 2007). The gluten content is directly correlated to the grain protein and it is strongly influenced by the climatic conditions. However, the wheat genotype is also one of the most important factors influencing the qualitative characteristics of gluten (Šimić, et al. 2006). Increase in total protein content of the flour positively correlates to the gluten content (Perten et al., 1992). Ratio between wet gluten (WG) content and grain protein (P) content (WG/P) is considered as an indicator of wet gluten production per protein unit. Šimić et al. (2006) reported that wheat genotypes with WG/P ratios ranging between 2.7 and 3.0 have gluten with optimal baking characteristics, while cultivars with strong gluten characteristics showed the WG/P ratio closer to 2.3.

The sedimentation value measures the sedimentation volume of gluten in the flour dispersion and it is a function of its gluten content and the gluten quality. Thus, the sediment obtained is related to the swelling of glutenins, which are associated with the bread making quality of flours (Mutlu et al., 2011).

All these quality parameters are affected by many factors, particularly genotype, locality and growing conditions and furthermore by harvesting method, postharvest treatment and storage. Thereby it is possible to explain the differences in the technological quality of wheat industrially manufactured in various regions and various years (Hruskova et al., 2004).

The objective of this study was to analyse the effect of growing season on some important quality parameters, such as protein content, wet and dry gluten contents and sedimentation value, in a set of old and new wheat varieties, registered and grown in Serbia during last 60 years.

## MATERIAL AND METHODS

The field trials were set on the experimental field of the Institute of Field and Vegetable Crops, Novi Sad, Serbia, during two growing seasons (2009/10 and 2010/11). The study was conducted with 25 winter wheat varieties registered and cultivated in Serbia for the last 60 years. The randomized complete block design with three complete blocks was used and standard agronomical practice for wheat growing in Serbia was applied. Kernel samples from the trials were mechanically harvested while further analyses were done in laboratory.

The important wheat quality parameters (protein content – PC, sedimentation value – SD, wet gluten content – WG and dry gluten content – DG) were analysed in each growing season. The protein content of the samples was determined using standard analytical (AACC, 2000) method 46-16.01. Sedimentation value was determined by Zeleny sedimentation test standard analytical (AACC, 2000) method 56-61.02, while for WG and DG manual methods were applied by SRPS EN ISO 21415-1 and SRPS EN ISO 21415-3, respectively.

In order to analyse the effect of the growing season on quality parameters of wheat, the meteorological conditions during trials were obtained from the Republic Hydro-meteorological Service of Serbia. During wheat growing season (from October to July) the following climatic variables were collected: minimum temperature (Mint, °C), maximum temperature (Maxt, °C), and total precipitations (Rainfall, mm) (Figure 1).

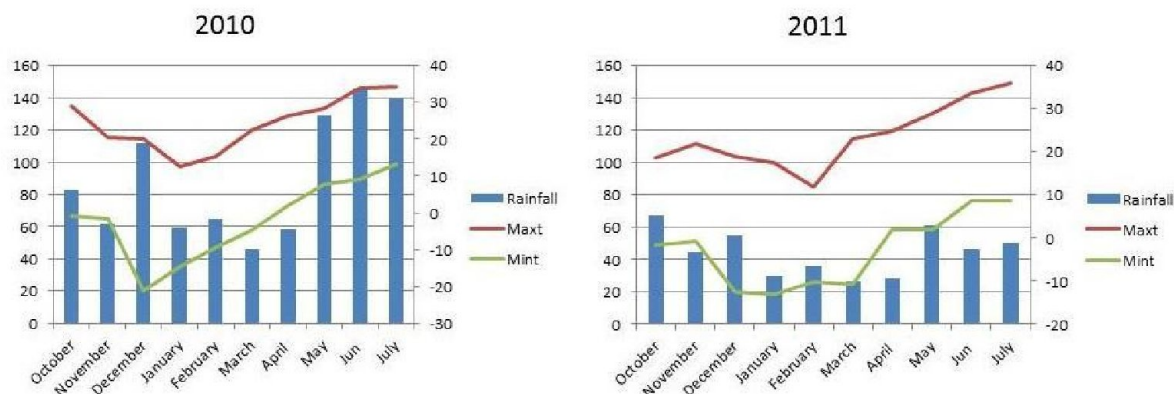


Figure 1. Basic meteorological data: minimum temperature (Mint, °C), maximum temperature (Maxt, °C), and total precipitations (Rainfall, mm) in two growing seasons.

The basic variability indicators (mean, standard deviation - StDev, and coefficient of variation - CV) for each trait, comparison of means, as well as the Pearson correlation coefficients among them were calculated in STAR- Statistical Tool for Agricultural Research v. 2.0.1.program.

## RESULTS AND DISCUSSION

The results for investigated quality parameters are shown in Table 1. The protein content of the wheat varieties ranged between 13.9 (cvs. NS 40S and Zlatna Dolina) and 16.5% (cvs. Banatka and Bankut-1206) in 2010 and between 12.8 (cv. Simonida) and 15.4% (Banatka) in 2011, indicating strong genotype and year effects on this trait. The overall mean for PC was 14.3%, with coefficient of variation (CV) of 6.8%, showing high potential for PC in the

material. Sedimentation value also varied significantly among cultivars and years, with average values of 41.2 ml in 2010 and 33.1 ml in 2011, and CV of 12.8%. Significant difference was found between average values for WG obtained in two growing seasons (32.6 and 31.0% in 2010 and 2011, respectively). The dry gluten content varied significantly among the cultivars (from 8.7 to 12.9%), with CV of 11.3%, but not between the years.

Table 1. Quality parameters (PC, SV, WG and DG9) of 25 winter wheat varieties with different years of release (YOR) in two growing seasons.

Genotype	YOR	PC (%)		SD		WG		DG	
		2010	2011	2010	2011	2010	2011	2010	2011
Banatka	1955	16.5	15.4	28.0	24.3	34.3	33.5	11.5	11.2
Bankut-1206	1955	16.5	14.9	44.7	33.2	38.8	38.0	12.9	12.4
San Pastore	1958	14.4	13.2	25.7	20.3	31.6	28.9	10.9	9.6
Bezostaja 1	1959	15.4	14.2	43.3	37.7	33.4	37.6	11.2	12.6
Libelula	1962	14.5	13.7	32.7	26.7	32.4	30.6	10.8	10.2
Zlatna Dolina	1970	13.9	13.8	35.8	27.3	31.8	30.2	10.7	10.4
Sava	1970	15.3	14.7	35.8	31.7	33.3	33.3	11.0	11.2
Partizanka	1973	14.8	13.8	40.3	35.2	33.0	30.9	11.0	10.5
Ns Rana 2	1975	14.9	14.3	41.0	36.7	31.1	31.1	10.4	10.4
KG 56	1975	15.2	13.7	44.2	36.3	32.6	31.2	10.9	10.4
Balkan	1979	14.9	13.8	45.8	35.0	31.7	30.5	10.7	10.2
Jugoslavija	1980	15.2	13.8	41.2	31.3	32.6	30.4	10.9	10.1
Skopljanka	1982	15.3	13.7	41.0	31.0	32.9	29.5	11.0	9.7
Lasta	1987	14.7	13.2	38.7	30.8	27.6	26.1	9.4	8.7
Evropa 90	1990	14.5	13.2	42.2	35.8	31.2	29.9	10.4	10.0
Ns Rana 5	1990	15.0	13.5	45.7	33.7	32.2	30.5	10.9	10.2
Pobeda	1992	15.3	13.5	48.3	35.7	34.7	31.9	11.5	10.5
Renesansa	1994	15.6	13.2	43.3	33.0	34.5	31.0	11.2	10.4
Pesma	1995	15.1	13.7	50.0	37.0	32.9	31.4	11.0	10.3
Ljiljana	2000	14.5	13.3	37.3	33.7	32.3	29.7	10.8	9.8
Cipovka	2002	14.8	13.9	45.0	34.3	32.6	31.4	10.9	10.5
Dragana	2002	14.4	13.3	36.2	33.2	32.2	30.8	10.8	10.2
Simonida	2003	14.0	12.8	43.2	34.3	32.4	28.5	10.9	9.5
NS 40S/00	2006	13.9	13.4	50.0	40.2	27.3	27.7	9.2	9.3
Zvezdana	2006	14.8	13.6	51.7	38.0	34.7	30.8	11.6	10.3
<b>Mean</b>		14.9 <sup>a</sup>	13.7 <sup>b</sup>	41.2 <sup>a</sup>	33.1 <sup>b</sup>	32.6 <sup>a</sup>	31.0 <sup>b</sup>	10.9 <sup>a</sup>	10.4 <sup>a</sup>
<b>Total mean</b>		14.3		37.5		31.8		10.6	
<b>StDev</b>		1.2		7.9		3.6		1.2	
<b>CV (%)</b>		6.8		12.8		10.2		11.3	

The first growing season was characterised with significantly higher amount of precipitation than the second, while temperature conditions were similar in the both seasons. The most of the quality parameters had significantly higher values in the first then in the second growing season (Table 1), indicating a high importance of the water supply for baking quality of wheat.

Hruskova et al. (2004) in their study on the quality of commercial wheat manufactured in an industrial mill over the years 2001 and 2002 reported no significant difference between the years in protein content (2001 – average 12.4%. 2002 – average 12.8%) and Zeleny test (2001 – average 52 ml. 2002 – average 55 ml). The average values for PC obtained in this study are significantly lower, while for SD are significantly higher than in our experiment. They used modern commercially used wheat varieties, different analytical methodologies and

also had very similar growing conditions in both seasons, while in our study old and new varieties are used and growing seasons differed significantly in temperature and precipitation conditions (Figure 1).

In the study of Mutlu et al. (2015), Zeleny value was measured between 19 and 63 ml, with the average value of 33.9 ml, which is very close to our results. They also stated that wheat flour with more than 36 ml of Zeleny sedimentation value is considered as a good quality. In the present study, 20 genotypes in 2010 and 6 genotypes in 2011 had more than 36 ml of Zeleny sedimentation value, indicating more favourable conditions for this quality trait in the first growing season.

The Pearson correlation coefficients showed significant positive associations between PC and WG, PC and DG, and WG and DG in both growing seasons (Table 2). Similar results were obtained by other authors (Šíp et al., 2000; Mutlu et al., 2015). Sedimentation value had no significant correlations with other traits, which is not in agreement with findings of other authors (Kučerová, 2006; Laidig et al., 2017).

Table 2. Correlations among quality parameters (PC, SD, WG and DG) of 25 winter wheat varieties with different years of release (YOR) and during two growing seasons.

	2010					2011				
	PC	SD	WG	DG	YOR	PC	SD	WG	DG	YOR
PC		0.014	0.695	0.679	-0.473		-0.171	0.721	0.733	-0.660
SD	0.014		0.067	0.021	0.583	-0.171		0.101	0.075	0.565
WG	0.695	0.067		0.991	-0.318	0.721	0.101		0.991	-0.530
DG	0.679	0.021	0.991		-0.366	0.733	0.075	0.991		-0.559
YOR	-0.473	0.583	-0.318	-0.366		-0.660	0.565	-0.530	-0.559	

In our study all estimated correlations were less pronounced in the first and stronger in the second growing season. Other authors who described the relationships between quality parameters of wheat varieties (Muchová, 2003; Werteker, 2003; Zimolka et al., 2005), also reported that environmental factors have an influence on quality traits and their relationships. When quality parameters were correlated with the year of release, it was shown that only SD was positively correlated, while other traits were in negative correlations with the YOR (Table 2). It means that older wheat varieties had higher protein content, as well as wet and dry gluten contents, but lower sedimentation values than modern cultivars. High baking quality of grain is usually negatively correlated with grain yield. Since wheat breeding during last 60 years was mostly focused to higher yield it consequently caused a decrease of some quality parameters in modern wheat cultivars. Fortunately, high yield does not necessary indicates low quality and low yield high quality (Kučerová, 2006). It was also proved in our study because significant genotypic variations were found for all the analysed traits and varieties with good quality parameters could be identified among old and new cultivars.

It was also confirmed in the study of Laidig et al. (2017) investigating breeding progress, environmental variation and correlation of winter wheat yield and quality traits in German official variety trials and on-farm during 1983–2014. They found a large gain in grain yield (24%), but a strong decline in protein concentration (-8.0%) and loaf volume (-8.5%) relative to 1983. Improvement of baking quality was achieved for falling number (5.8%), sedimentation value (7.9%), hardness (13.4%), water absorption (1.2%) and milling yield (2.4%). Grain yield, falling number and protein concentration were highly influenced by environment, whereas for sedimentation value, hardness, water absorption and loaf volume genotypes accounted for more than 60% of total variation. Breeding progress was very successfully transferred into both progress in grain yield and on-farm baking quality.

On the other hand, Migliorini et al. (2016) analysed agronomic and quality characteristics of old, modern and mixture wheat varieties and landraces for organic bread chain in diverse environments of northern Italy. They reported that the bread produced with old wheat varieties was preferred by consumers when compared with the bread produced with modern wheat varieties. The old varieties and their mixtures yielded less than the modern varieties but with higher stability and robustness. Therefore, the use of old bread wheat varieties and

their mixtures, assessed with participatory and evolutionary plant breeding, in some cases could represent a strategy for local communities to cope with climate change while improving food security and food quality.

## CONCLUSION

The obtained results have shown a large variation among the genotypes for all investigated traits in different growing seasons. The most of the quality parameters had higher values in the first season with high precipitation, indicating that by providing the optimal water supply during wheat growth and development the baking quality could be significantly improved. The most variable trait was SD, while the variations of PC were significantly lower. PC was positively correlated with the wet and dry gluten contents. The established correlations between the traits and the year of release of the genotypes have shown that older wheat varieties had higher protein content, as well as wet and dry gluten contents, but lower sedimentation values than the modern cultivars. All estimated correlations were less pronounced in the first (more favourable) and stronger in the second growing season (less favourable for wheat quality). It was possible to identify stable genotypes with high average values for each of the traits among the old and new cultivars. The identified genotypes can serve as parents in wheat breeding for high baking quality and high yield.

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