ИЗБОРНОМ ВЕЋУ
ПОЉОПРИВРЕДНОГ ФАКУЛТЕТА
УНИВЕРЗИТЕТА У БЕОГРАДУ

У складу са Законом о науци и истраживањима ("Службени гласник РС" бр. 49/2019) и Правилником о стицању истраживачких и научних звања ("Службени гласник РС" бр. 159/2020 и 14/2023) и на основу одлуке Изборног већа Пољопривредног факултета Универзитета у Београду бр. 400/2-7, 28.11.2024. године, именовани смо у Комисију за спровођење поступка стицања звања, подношења извештаја и оцене научноистраживачког рада кандидаткиње Јоване Марковић, мастер инжењера технологије, за избор у звање истраживач сарадник у области биотехничких наука, грана – прехрамбено инжењерство, научна дисциплина – технологија биљних производа, ужа научна дисциплина – методе конзервисања.

На основу увида у достављену документацију, Комисија у саставу: др Драгана Михајловић, редовни професор Пољопривредног факултета Универзитета у Београду, др Виктор Недовић, редовни професор Пољопривредног факултета Универзитета у Београду и др Верица Ђорђевић, доцент Технолошко-металуршког факултета Универзитета у Београду, подноси следећи:

ИЗВЕШТАЈ

Биографски подаци

Мастер инж. Јована (Миливоје) Марковић рођена је 19.04.1994. године у Аранђеловцу, Република Србија. Основну школу завршила је у Тополи, а средње образовање (Гимназија, природно-математички смер) стекла је у Аранђеловцу. Пољопривредни факултет Универзитета у Београду, студијски програм: Прехрамбена технологија, модул Технологија конзервисања и врења, уписала је школске 2013/14. године. Основне академске студије завршила је 2017. године, са општим успехом 9,85 и оценом 10 на завршном раду, под називом: „Примена и значај антиоксиданата у индустријској производњи готове хране". Школске 2017/18. године уписала је мастер академске студије на истом факултету, студијски програм: Прехрамбена технологија, модул Прехрамбени инжењеринг. Све испите предвиђене планом и програмом мастер академских студија положила је са просечном оценом 10,00. Мастер рад, под називом „Стабилност каротеноида при сувој и влажној топлотној обради бундеве", одбранила је 2018. године, са оценом 10.

Током основних и мастер академских студија, била је стипендиста Министарства просвете, науке и технолошког развоја и Фонда за младе таленте (стипендија „Доситеја") Министарства омладине и спорта Републике Србије. Школске 2016/17. године награђена је за изузетан успех током студија на Пољопривредном факултету Универзитета у Београду. Била је добитница награде за најбољег дипломираног студента Пољопривредног факултета 2017. године, коју додељује Задужбина „Никола Спасић".

Докторске академске студије на Пољопривредном факултету Универзитета у Београду, студијски програм: Прехрамбена технологија, уписала је школске 2018/19. године. Испите предвиђене планом и програмом докторских академских студија положила је са просечном

оценом 9,86. Веће научних области биотехничких наука је одлуком број 61206-55/2-23 дало сагласност на одлуку Наставно-научног већа Пољопривредног факултета Универзитета у Београду о прихватању теме докторске дисертације кандидаткиње, под називом: „Утицај инкапсулираног сока и лиофилизованог тропа корена и листа рена (*Armoracia rusticana* L.) на оксидативну стабилност и квалитет мајонеза током складиштења“ (Прилог 1). Кандидаткиња је ангажована као студент-демонстратор на Катедри за технологију конзервисања и врења, Пољопривредног факултета Универзитета у Београду, на предметима: Технологија готове хране и Функционална својства хране, на којима изводи лабораторијске вежбе од школске 2018/19. године до данас. Била је ангажована као стипендиста Министарства просвете, науке и технолошког развоја Републике Србије на пројекту: „Развој и примена нових и традиционалних технологија у производњи конкурентних прехрамбених производа са додатом вредношћу за домаће и европско тржиште - СТВОРИМО БОГАТСТВО ИЗ БОГАТСТВА СРБИЈЕ“ (евиденциони број пројекта ИИИ 46001) на Пољопривредном факултету Универзитета у Београду 2019. године. Од 2020. године ангажована је на истраживањима у оквиру Уговора о реализацији и финансирању научноистраживачког рада између Пољопривредног факултета Универзитета у Београду и Министарства науке, технолошког развоја и иновација Републике Србије (евиденциони број уговора за 2024. годину: 451-03-65/2024-03/200116). На истом факултету, изабрана је у звање истраживач приправник од 2022. године, у области биотехничких наука, грана – прехрамбено инжењерство, научна дисциплина – технологија биљних производа, ужа научна дисциплина – методе конзервисања.

Научноистраживачки рад

Кандидаткиња је у досадашњем раду показала изузетно интересовање и склоност ка научностраживачком раду. Заједно са колегама у Централној лабораторији Катедре за технологију конзервисања и врења, Пољопривредног факултета Универзитета у Београду, активно учествује у више експеримената из области функционалних својстава хране, инкапсулације биоактивних компонената хране, испитивања антиоксидативне активности биљних екстраката, формулисања и карактеризације готових прехрамбених производа.

Кандидаткиња је до сада, у сарадњи са другим ауторима, објавила 27 публикација, од којих 4 рада у међународним часописима (један у категорији М21а, два у категорији М21 и један у категорији М23), 2 рада у националном часопису међународног значаја (категорија М24), 20 саопштења на међународним научним скуповима (категорија М34) и 1 саопштење на националном научном скупу (категорија М64). Библиографија је наведена у Прилогу 2, а објављене публикације у Прилогу 3 овог Извештаја.

Закључак и предлог

На основу поднете документације и анализе научноистраживачког и стручног рада истраживача приправника Јоване Марковић, мастер инжењера технологије, Комисија закључује да је кандидаткиња постигла запажен успех у научном раду. Резултати, усвајање метода научноистраживачког рада, као и залагање и ентузијазам у погледу научног напредовања квалификују је за избор у више истраживачко звање. Оваквим приступом она се развија у перспективног научног радника из области прехрамбене технологије.

Комисија је јединствена у оцени и закључку да истраживач приправник **Јована Марковић**, мастер инжењер технологије, испуњава све потребне услове дефинисане Законом о науци и истраживањима ("Службени гласник РС" бр. 49/2019) и Правилником о стицању истраживачких и научних звања ("Службени гласник РС" бр. 159/2020 и 14/2023) и у складу са тим предлаже Изборном већу и Декану Пољопривредног факултета Универзитета у Београду да Јовану Марковић, мастер инжењера технологије, изабере у звање **истраживач сарадник** у области биотехничких наука, грана – прехрамбено инжењерство, научна дисциплина – технологија биљних производа, ужа научна дисциплина – методе конзервисања.

У Београду, 29.11.2024. године.

ЧЛАНОВИ КОМИСИЈЕ

др Драгана Михајловић, редовни професор

Универзитет у Београду – Пољопривредни факултет

(ужа научна област: Наука о конзервисању и врењу)

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Универзитет у Београду – Пољопривредни факултет

(ужа научна област: Наука о конзервисању и врењу)

др Верица Ђорђевић, доцент

Универзитет у Београду – Технолошко-металуршки факултет

(ужа научна област: Хемијско инжењерство)

Прилог 1.

УНИВЕРЗИТЕТ У БЕОГРАДУ

Адреса: Студентски трг 1, 11000 Београд, Република Србија
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ВЕЋЕ НАУЧНИХ ОБЛАСТИ
БИОТЕХНИЧКИХ НАУКА

Београд, 17. јануар 2023. године
02-08 Број: 61206-55/2-23
МЦ

На основу члана 48 став 5 тачка 3 Статута Универзитета у Београду („Гласник Универзитета у Београду", бр. 201/18, 207/19, 213/20, 214/20, 217/20, 230/21, 232/22 и 233/22) и члана 32 Правилника о докторским студијама на Универзитету у Београду („Гласник Универзитета у Београду", бр. 191/16, 212/19, 215/20, 217/20, 228/21 и 230/21), а на захтев Пољопривредног факултета, бр. 32/13-4.1. од 28. децембра 2022. године, Веће научних области биотехничких наука, на седници одржаној 17. јануара 2023. године, донело је

О Д Л У К У

ДАЈЕ СЕ САГЛАСНОСТ на одлуку Наставно-научног већа Пољопривредног факултета о прихватању теме докторске дисертације ЈОВАНЕ МАРКОВИЋ, под називом: „Утицај инкапсулираног сока и лиофилизованог тропа корена и листа рена (*Armoracia rusticana* L.) на оксидативну стабилност и квалитет мајонеза током складиштења" и одређивању проф. др Драгане Михајловић и проф. др Виктора Недовића за менторе.

ПРЕДСЕДНИЦА ВЕЋА
проф. др Мирјана Опачић

Доставити:
- Факултету
- архиви Универзитета

Прилог 2. Списак саопштених и објављених научних и стручних радова кандидаткиње

Рад у међународном часопису изузетних вредности (M21a = 10)

1. **Marković, J.**, Salević-Jelić, A., Milinčić, D., Gašić, U., Pavlović, V., Rabrenović, B., Pešić, M., Lević, S., Mihajlović, D., Nedović, V. (2024). Horseradish (*Armoracia rusticana* L.) leaf juice encapsulated within polysaccharides-blend-based carriers: Characterization and application as potential antioxidants in mayonnaise production. *Food Chemistry*, *464*(2025), 141777. https://doi.org/10.1016/j.foodchem.2024.141777

Рад у врхунском међународном часопису (M21 = 8)

1. **Marković, J. M.**, Salević-Jelić, A. S., Milinčić, D. D., Gašić, U. M., Pavlović, V. B., Rabrenović, B. B., Pešić, M. B., Lević, S. M., Nedović, V. A., Mihajlović, D. M. (2024). Encapsulated horseradish (*Armoracia rusticana* L.) root juice: Physicochemical characterization and the effects od its addition on the oxidative stability and quality of mayonnaise. *Journal of Food Engineering*, *381*(2024), 112189. https://doi.org/10.1016/j.jfoodeng.2024.112189

2. Belošević, S. D., Milinčić, D. D., Gašić, U. M., Kostić, A. Ž., Salević-Jelić, A. S., **Marković, J. M.**, Đorđević, V. B., Lević, S. M., Pešić, M. B., Nedović, V. A. (2024). Broccoli, amaranth, and red beet microgreen juices: The influence of cold-pressing on the phytochemical composition and the antioxidant and sensory properties. *Foods*, *13*, 757. https://doi.org/10.3390/foods13050757

Рад у међународном часопису (M23 = 3)

1. Mihajlović, D., Čolić, S., **Marković, J.**, Perišić, D., Rajić, J., Premović, T., Rabrenović, B. (2023). Heat treatment effect on tocopherols, total phenolics and fatty acids in table olives (*Olea europaea* L.). *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *51*(1). https://doi.org/10.15835/nbha51113029

Рад у националном часопису међународног значаја (M24 = 3)

1. Paunović, D. M., Demin, M. A., Petrović, T. S., **Marković, J. M.**, Vujasinović, V. B., Rabrenović, B. B. (2020). Quality parameters of sunflower oil and palm olein during multiple frying. *Journal of Agricultural Sciences*, *65*(1), 61-68. https://doi.org/10.2298/JAS2001061P
2. Paunović, D. M., **Marković, J. M.**, Stričević, L. P., Vujasinović, V. B., Rabrenović, B. B. (2021). The influence of cutting thickness, shape and moisture content on oil absorption during potato frying. *Journal of Agricultural* Sciences, *66*(1), 67-74. https://doi.org/10.2298/JAS2101067P

Саопштење са међународног скупа штампано у изводу (М34 = 0,5)

1. Paunović, D. M., **Marković, J. M.**, Ivanović, E. R., Rabrenović, B. B., Despotović, S. M., Banjac, N. R. (2019). Stability of carotenoids in pumpkin during the different heat treatments. 1st International Conference on Advanced Production and Processing (pp. 32). 10-11 October, Novi Sad, Serbia. ISBN 978-86-6253-102-5

2. Paunović, D. M., Demin, M. A., Petrović, T. S., **Marković, J. M.**, Vujasinović, V. B., Rabrenović, B. B. (2019). The quality of sunflower oil and palm olein during the production of french fries. 1st International Conference on Advanced Production and Processing (pp. 34). 10-11 October, Novi Sad, Serbia. ISBN 978-86-6253-102-5

3. Paunović, D. M., **Marković, J. M.**, Rabrenović, B. B., Laličić-Petronijević, J. G., Rajić, J. R., Petrović, T. S. (2021). The influence of different heat treatment on the vitamin c content in pepper (*Capsicum annuum* L.). Book of Abstracts of 2nd International UNIfood Conference, University of Belgrade (pp. 180). 24th-25th September, Belgrade, Serbia. ISBN 978-86-7522-066-4

4. Despotović, S., Paunović, D., **Marković, J.**, Nedović, V., Djordjević, S., Veljović, S., Martinović, A. (2021). Medicinal and aromatic herbs as functional ingredients for specialty beverages. Book of Abstracts of IBSC International Bioscience Conference and the 8th International PSU – UNS Bioscience, Conference Towards the SDG Challenges (pp. 94-95). 25th-26th November, Novi Sad, Serbia.

5. **Marković, J.**, Mihajlović, D., Mašković, P., Banjac, N., Mašković, J., Ivanović, E. (2022): Effect of different heat treatments on antioxidative activity in pumpkin (*Cucurbita maxima*). Book of abstracts of 1 st European Symposium on Phytochemicals in Medicine and Food (1-EuSPMF) (pp.72). 7th-9th September, Belgrade, Serbia. ISBN 978-86-7834-408-4

6. **Marković, J. M.**, Nedović, V. A., Salević-Jelić, A. S., Pejić, L. D., Mihajlović, D. M. (2023). The possibility of using horseradish leaves pomace in the food industry. Book of Abstracts of 6th International Symposium of Agricultural Engineering (pp. 44). 19th-21st October, Belgrade, Serbia. ISBN 978-86-7834-423-7

7. **Marković, J.**, Nedović, V., Salević-Jelić, A., Lević, S., Đorđević, V., Belošević, S., Mihajlović, D. (2023). Antioxidant potential and phenolics content of horseradish root juice encapsulated within different carbohydrate matrices. Book of Abstracts of International Conference on Biochemical Engineering and Biotechnology for Young Scientists (pp. 52), 7th-8th December, Belgrade, Serbia. ISBN 978-86-7401-389-2

8. **Marković, J.**, Mihajlović, D., Salević-Jelić, A., Lević, S., Đorđević, V., Belošević, S., Nedović, V. (2023). Physicochemical characterization of spray-dried horseradish root juice encapsulated within maltodextrin/alginate. Book of Abstracts of International

Conference on Biochemical Engineering and Biotechnology for Young Scientists (pp. 53), 7th-8th December, Belgrade, Serbia. ISBN 978-86-7401-389-2

9. Belošević, S. D., Milinčić, D. D., Salević-Jelić, A. S., **Marković, J. M.**, Lević, S. M., Pešić, M. B., Đorđević, V. B., Marjanović S. M., Nedović, V. A. (2023). Broccoli microgreens-apple juice as novel beverages: total phenolic, flavonoids and antioxidant activity. Book of Abstracts of International Conference on Biochemical Engineering and Biotechnology for Young Scientists. (pp.68). 7th-8st December, Belgrade, Serbia. ISBN 978-86-7401-389-2.

10. Belošević, S. D., Milinčić, D. D., Salević-Jelić, A. S., **Marković, J. M.**, Lević, S. M., Pešić, M. B., Đorđević, V. B., Marjanović S. M., Nedović, V. A. (2023). Characterization of amaranth (*Amaranthus tricolor L.*) microgreens juice encapsulated within inulin and maltodextrin. Book of Abstracts of International Conference on Biochemical Engineering and Biotechnology for Young Scientists. (pp.69). 7th-8st December, Belgrade, Serbia. ISBN 978-86-7401-389-2

11. **Marković, J. M.**, Salević-Jelić, A. S., Belošević, S. D., Pejić, L., D., Rabrenović, B. B., Lević, S. M., Nedović, V. A., Mihajlović, D. M. (2024). Encapsulated horseradish leaf juice: A potential alternative to synthetic antioxidants in mayonnaise production. Book of Abstracts of 3rd International UNIFood Conference, University of Belgrade (pp. 119). 28th-29th June, Belgrade, Serbia. ISBN 978-86-7834-438-1

12. **Marković, J. M.**, Salević-Jelić, A. S., Milinčić, D. D., Belošević, S. D., Gašić, U. M., Đorđević, V. B., Pešić, M. B., Lević, S. M., Mihajlović, D. M., Nedović, V. A. (2024). Horseradish leaf juice encapsulates: Physicochemical, spectrophotometric, and chromatographic characterization. Book of Abstracts of 3rd International UNIFood Conference, University of Belgrade (pp. 160). 28th-29th June, Belgrade, Serbia. ISBN 978-86-7834-438-1

13. Belošević, S. D., Milinčić, D. D., Salević-Jelić, A. S., **Marković, J. M.**, Lević, S. M., Pešić, M. B., Marjanović, S. M., Đorđević, V. B., Nedović, V. A. (2024). Encapsulation of broccoli microgreen juice: Phytochemical composition and antioxidant activity. Book of Abstracts of 3rd International UNIFood Conference, University of Belgrade (pp. 38). 28th-29th June, Belgrade, Serbia. ISBN 978-86-7834-438-1

14. Belošević, S. D., Milinčić, D. D., Salević-Jelić, A. S., **Marković, J. M.**, Pavlović, V. B., Lević, S. M., Pešić, M. B., Marjanović, S. M., Đorđević, V. B., Nedović, V. A. (2024). The influence of carbohydrate carriers on the morphology and physical properties of red beet microgreen juice encapsulates. Book of Abstracts of 3rd International UNIFood Conference, University of Belgrade (pp. 157). 28th-29th June, Belgrade, Serbia. ISBN 978-86-7834-438-1

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Horseradish (*Armoracia rusticana* L.) leaf juice encapsulated within polysaccharides-blend-based carriers: Characterization and application as potential antioxidants in mayonnaise production

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ABSTRACT

This study aimed to encapsulate cold-pressed horseradish leaf juice within maltodextrin/alginate (MD/AL), maltodextrin/guar gum (MD/GG), and maltodextrin/gum Arabic (MD/GA) by spray-drying, to characterize the encapsulates, and to test their potential as mayonnaise oxidation-preventing ingredients. The encapsulates exhibited desirable physicochemical, morphological, structural, and thermal properties, highlighting MD/GA-containing encapsulates, especially regarding high encapsulation yield (78.50 %). Also, encapsulates contained a significant amount of phenolics, which were stable during freezer storage. The encapsulates successfully delayed the mayonnaise oxidation: 31.91–38.94 % more than the synthetic antioxidant ethylenediaminetetraacetic acid, especially highlighting MD/AL-containing encapsulates. Also, the encapsulates improved product quality with a higher pH and lower acidity after storage compared to the controls. Overall acceptability of encapsulates-containing mayonnaises and commercial mayonnaise did not differ significantly. This study contributes to sustainable development by providing new insights into the valorization of horseradish leaves, as a promising alternative to synthetic additives to prolong the oxidative stability and shelf-life of high-oil-containing foods.

1. Introduction

Despite the increasing consumer trend towards lower-calorie products, mayonnaise is still one of the most consumed high-oil-containing sauces worldwide (Mirzanajafi-Zanjani et al., 2019). Its special mild flavor, attractive texture, and creamy mouthfeel make it a very popular product served on tables all over the world (Blejan & Nour, 2023), usually alongside salads, sandwiches, and many other food products. However, due to the lipid structure i.e., composition and content (approximately 70–80 %), it is very susceptible to oxidative damage, resulting in the formation of rancid flavor, changes in aroma, color, and texture, as well as a reduction of nutritional value and shelf-life (Blejan & Nour, 2023; Minusian et al., 2024). During homogenization, a large surface area of the oil is exposed to the oxygen dissolved in the aqueous phase and the air bubbles trapped in the emulsion, which contributes to the intensification of oxidative reactions in mayonnaise (Moradi et al., 2023). The effect of external energy (such as light) on unsaturated lipids in the presence of catalysts (such as transition metals) leads to the formation of free radicals (Ghorbani Gorji et al., 2016). The resulting free radicals react with molecular oxygen and form peroxide radicals (primary oxidation products). They are tasteless, but can be further decomposed into aldehydes, ketones, alcohols, hydrocarbons, volatile organic acids, and epoxy compounds (secondary oxidation products), which are responsible for the rancid flavor of mayonnaise (Ghorbani

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Encapsulated horseradish (*Armoracia rusticana* L.) root juice: Physicochemical characterization and the effects of its addition on the oxidative stability and quality of mayonnaise

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ABSTRACT

The cold-pressed horseradish (*Armoracia rusticana* L.) root juice was used for spray-drying encapsulation within different biopolymeric carriers (maltodextrin/alginate, maltodextrin/guar gum, and maltodextrin/gum Arabic) to ensure easier handling and preservation of its bioactive compounds. The obtained encapsulates were added in mayonnaise formulations as potential substitutes for synthetic antioxidants. Physicochemical, spectrophotometric, and chromatographic analyses of the encapsulates showed the presence of various phenolic compounds and a pronounced antioxidant activity. The encapsulates were stable in terms of total phenolic content retention over 6 months of storage at −18 °C. The determination of the peroxide and *p*-anisidine values as well as the accelerated oxidation stability analysis showed that the horseradish encapsulates added to the mayonnaise were more potent in maintaining the oxidative stability of the mayonnaise than the synthetic antioxidant. The added encapsulates positively affected the pH and acid values of the mayonnaises. Also, mayonnaises with encapsulates were sensory acceptable. These results suggest that encapsulated horseradish root juice within various carriers could find useful application as a natural antioxidant in food products to prevent oxidation and prolong shelf-life.

1. Introduction

Although people have recently been tending towards healthier diets and lower calorie intake, mayonnaise is still a very popular condiment due to its delicious taste, appealing texture, and creamy mouthfeel (Mirzanajafi-Zanjani et al., 2019). Mayonnaise can be stored at room temperature, but its quality deteriorates over time due to autoxidation of the unsaturated fatty acids (Ghorbani Gorji et al., 2016). Various synthetic antioxidants such as TBHQ (t-butylhydroxyquinone), EDTA (ethylenediaminetetraacetic acid), BHA (butylhydroxyanisole), and BHT (butylhydroxytoluene) are usually used in the mayonnaise production, effectively suppressing oxidation and prolonging the shelf-life of this product (Ahmadi-Dastgerdi et al., 2019; Chotphruethipong and Benjakul, 2019). They are characterized by high stability, low cost, good scavenging activity, and easy procurement (Xu et al., 2021). However, some studies have identified synthetic antioxidants as toxicological and carcinogenic agents (Eskandani et al., 2014; Ogundele, 1999; Xu et al., 2021). Therefore, due to concerns about synthetic food additives, consumer demand for healthy foods and the use of antioxidants from natural sources is increasing (Kwon et al., 2015; Mitterer-Daltoé et al., 2020). Until now, extracts from rosemary (Savani et al., 2023), *Ferulago angulata* (Alizadeh et al., 2019), sage (Razmy et al., 2012), grape seed (Altunkaya et al., 2013), fruits/vegetables (Lazăr et al., 2022; Soltan et al., 2023), and various spices (Kwon et al., 2015) were successfully incorporated into mayonnaise, contributing to its prolonged oxidative stability. However, to our knowledge, the addition of encapsulated horseradish juice into mayonnaise has not yet been investigated.

Horseradish (*Armoracia rusticana* L.) belongs to the Brassicaceae family and is characterized by a strong, spicy flavor and odor as a result of isothiocyanates released by enzymatic hydrolysis of glucosinolates

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Article

Broccoli, Amaranth, and Red Beet Microgreen Juices: The Influence of Cold-Pressing on the Phytochemical Composition and the Antioxidant and Sensory Properties

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Abstract: The aim of this study was to analyze in detail the phytochemical composition of amaranth (AMJ), red beet (RBJ), and broccoli (BCJ) microgreens and cold-pressed juices and to evaluate the antioxidant and sensory properties of the juices. The results showed the presence of various phenolic compounds in all samples, namely betalains in amaranth and red beet microgreens, while glucosinolates were only detected in broccoli microgreens. Phenolic acids and derivatives dominated in amaranth and broccoli microgreens, while apigenin C-glycosides were most abundant in red beet microgreens. Cold-pressing of microgreens into juice significantly altered the profiles of bioactive compounds. Various isothiocyanates were detected in BCJ, while more phenolic acid aglycones and their derivatives with organic acids (quinic acid and malic acid) were identified in all juices. Microgreen juices exhibited good antioxidant properties, especially $ABTS^{\bullet+}$ scavenging activity and ferric reducing antioxidant power. Microgreen juices had mild acidity, low sugar content, and good sensory acceptability and quality with the typical flavors of the respective microgreen species. Cold-pressed microgreen juices from AMJ, RBJ, and BCJ represent a rich source of bioactive compounds and can be characterized as novel functional products.

Keywords: broccoli microgreens; amaranth microgreens; red beet microgreens; microgreen juices; antioxidant activity; apigenin C-glycosides

1. Introduction

Microgreens are recognized as new crops and potential foods of the future [1]. They represent a novel and promising source of highly valuable bioactive compounds with health-promoting effects [2–6]. The most commonly grown and studied microgreens are from the Brassicaceae and Amaranthaceae families with crops such as broccoli, cabbage, kale, argula, red beet, chard, amaranth, etc. [1]. So far, the aforementioned microgreen species have been mostly consumed in raw form or as culinary ingredients in dishes due to their high content of bioactive compounds and specific flavor [7]. Previous studies have shown that broccoli, amaranth and red beet microgreens are high in bioactive compounds

Mihajlović D *et al.* (2023)
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Research Article

Heat treatment effect on tocopherols, total phenolics and fatty acids in table olives (*Olea europaea* L.)

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Abstract

The olive fruits are rich source of oil, vitamins, minerals, organic acids and pigments. The fruits contain high level of bioactive compounds. The aim of this study was to examine the effect of heat treatment on tocopherols, total phenolics and antioxidant activity in green and black olives, as well as their fatty acid composition. The instrumental methods used in this experiment were high performance liquid chromatography (HPLC), gas chromatography with flame ionization detection (GC/FID) and spectrophotometric methods. The results revealed that the β+γ-tocopherols content after the heat treatment had the biggest reduction, which was 68.4% for green and 80.2% for black olives. Also, a significant loss of total phenolic content was observed after heat treatment in green and black olives by 18.6% and 18.4%, respectively, as well as antioxidant activity (decrease up to 28.1%). The most abundant fatty acids in green and black olives were oleic (C18:1), palmitic (C16:0) and linoleic acid (C18:2). The changes in fatty acids composition during the heat treatment occurred mostly at the level of polyunsaturated fatty acids, especially linolenic acid (C18:3) in black olives had the significant reduction (by 57.4%) in relation to the initial quantity.

Keywords: fatty acids; GC/FID; HPLC; olive; tocopherols; total phenolics

Introduction

The olive (*Olea europaea* L.) is one of the oldest and most important fruit in Mediterranean countries, which is grown for its edible fruits (Boskou, 2006). As the fruit ripens it changes colour from green to bluish-purple, and at full maturity it turns black (Boskou, 2006). The green colour of the fruits comes from chlorophyll, while the purple and bluish colour comes from anthocyanins. The black colour is formed by the oxidation of phenolic compounds including oleuropein (Boskou, 2006; Omar, 2010). The chemical

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QUALITY PARAMETERS OF SUNFLOWER OIL AND PALM OLEIN DURING MULTIPLE FRYING

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Abstract: The refined sunflower and palm oils are used in the food industry for the production of fried potatoes. Literary data have shown that palm oil had less tendency to degradation than sunflower oil due to its fatty acid composition. However, palm olein is a palm oil fraction and therefore has a different composition of fatty acids. The aim of this study was to investigate the quality of the refined palm olein in relation to the refined linoleic type sunflower oil during the production of fried potatoes. The oil samples were used for multiple frying during the seven days (40 minutes per day at a temperature of 165°C). The peroxide value and free fatty acid content (acid value) were determined by standard analytical methods. The results showed that the peroxide value in sunflower oil and palm olein increased by 75.0% and 77.8%, while the acid value increased by 50.0% and 26.8%, respectively, in relation to their initial values in the fresh oil samples. Based on these results, it can be concluded that the palm olein was more suitable for frying. However, this finding cannot be reported with certainty because the quality of the oil depends on many more parameters, not only on those analysed in this paper.

Key words: sunflower oil, palm olein, peroxide value, acid value.

Introduction

Potato frying is a widespread way of preparing potatoes for human consumption. The fried potatoes have a pleasant taste and a crunchy texture that make them very popular with consumers. The most common method of frying potatoes is deep frying in oil in the food industry as well as in the household. In industrial conditions, frying oil is used for a long period of time before being

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THE INFLUENCE OF CUTTING THICKNESS, SHAPE AND MOISTURE CONTENT ON OIL ABSORPTION DURING POTATO FRYING

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Abstract: Potato chips and French fries are products which are often used in the human diet. The aim of this study was to investigate the influence of cutting thickness, shape and moisture content on palm olein uptake, as well as the quality of the palm olein during the production of fried potatoes. Blanching operation was conducted in water for 3 minutes at a temperature of 85°C, while the frying process was conducted in palm olein for 3 minutes at a temperature of 165°C. The peroxide value and free fatty acid content (% oleic acid) were determined by standard analytical methods. The oil content in samples was determined by the standard Soxhlet extraction (the reference method). The results showed that the potato chips had approximately four times more oil uptake compared to potato sticks. The oil content was significantly lower in blanched potato slices (by 43.3%) but significantly higher in blanched potato sticks (by 53.5%) compared to unblanched samples. The analyzed quality parameters of palm olein were within the allowable value range. Based on the results obtained in this study, it can be concluded that the thickness, surface area and moisture content of the potato had a significant effect on oil uptake.

Key words: fried potato, palm olein, surface area, peroxide value, free fatty acids content.

Introduction

The potato (*Solanum tuberosum*) is a tuberous vegetable that is the most commonly used in human nutrition. The reasons for its widespread use are that the potato has a favourable economic factor, and it is available throughout the year (Popović-Djordjević et al., 2018). In terms of nutrition value, this vegetable is a

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STABILITY OF CAROTENOIDS IN PUMPKIN DURING THE DIFFERENT HEAT TREATMENTS

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Pumpkin contains high content of carotenoids, the majority of which are alpha-carotene, beta-carotene, alpha-cryptoxanthin, lutein/zeaxanthin and violaxanthin. The main beneficial effect of carotenoids derives from their antioxidant activity, i.e. protecting cells against the harmful effects of free radicals. The aim of this study was to determine the content of total pumpkin carotenoids during cooking, baking in oven and microwave oven to examine how different heat treatments affect the stability of the carotenoids. The standard spectrophotometric method was used to determine the content of total carotenoids, measuring the absorbance of extracted samples at a wavelength of 445 nm. Samples were extracted by petrolether. According to the obtained results, the highest content of carotenoids was in raw pumpkin (172.93 μg/g dry matter), then in an oven baked pumpkin (66.63 μg/g dry matter), then in a microwave oven baked pumpkin (65.97 μg/g dry matter) and the lowest content of total carotenoids was determined in cooked pumpkin (54.42 μg/g dry matter). These results indicated that different heat treatments significantly affected the stability of carotenoids in pumpkin. The higher losses were during cooking, while the losses of baking in the oven and microwave oven were similar.

Keywords: pumpkin, heat treatment, total carotenoids, spectrophotometry

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THE QUALITY OF SUNFLOWER OIL AND PALM OLEIN DURING THE PRODUCTION OF FRENCH FRIES

Dragana M. Paunović*[1], Mirjana A. Demin[1], Tanja S. Petrović[1], Jovana M. Marković[1], Vesna B. Vujasinović[2], Biljana B. Rabrenović[1]

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The refined sunflower and palm oil are used in the food industry for the production of French fries. Literary data have been shown that the palm oil had less tendency to degradation than sunflower oil, due to its fatty acid composition. However, palm olein is a palm oil fraction and therefore has a different composition of fatty acids. The aim of this study was to investigate quality of the refined palm olein in relation to the refined sunflower oil during the production of French fries. The oil samples were used for multiple frying during seven days (40 minutes per day at a temperature of 165 °C). The peroxide number and free fatty acids content (acid number) were determined by standard analytical methods. The results showed that the peroxide number in sunflower oil and palm olein increased by 75.0% and 77.8%, while the acid number increased by 50.0% and 26.8%, respectively, in relation to their initial values in fresh oil samples. Based on these results it can be concluded that the palm olein was more suitable for frying. However, this finding cannot be indicated with certainty because the quality of the oil depends on many more parameters, not only of analyzed in this paper.

Keywords: sunflower oil, palm olein, peroxide number, acid number

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THE INFLUENCE OF DIFFERENT HEAT TREATMENT ON THE VITAMIN C CONTENT IN PEPPER (CAPSICUM ANNUUM L.)

***Dragana M. Paunović*[1], *Jovana M. Marković*[1], *Biljana B. Rabrenović*[1], *Jovanka G. Laličić-Petronijević*[1], *Jasmina R. Rajić*[2], *Tanja S. Petrović*[1]**

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The pepper (**Capsicum annuum** L.) is a vegetable commonly used in the human diet. Due to its exceptional sensory and nutritional properties, it is readily consumed both fresh and processed into various ready meals, pickling, salads, dried spices, etc. There are a large number of cultivars of peppers that differ in shape, size, color, aroma, degree of hotness, etc. The pepper is a rich source of carotenoids, vitamins, mineral matter, carbohydrates, organic acids and aromatic components. Numerous bioactive compounds found in pepper, such as vitamin C (ascorbic acid), contribute to its high antioxidant activity.

The aim of this study was to determine the vitamin C content after different heat treatments commonly used in the industrial processing of peppers, as well as in the household. The domestic cultivar "Elephant ear" was subjected to tree different thermal treatments: 1) cooked in a closed and opened dish, 2) roasting in microwave oven and on the hob, and 3) frying in sunflower oil, for 15 minutes. The content of vitamin C was determined using the indirect iodimetry method. The results were expressed in mg/100 g dry basis (d.b.) and compared with the fresh pepper used as a control. The content of vitamin C in the fresh sample was 1295.38 mg/100 g d.b., while in the peppers cooked in closed and opened dish its value was 1007.58 and 615.17 mg/100 g d.b., respectively. In the pepper treated in the microwave oven and on the hob, the content of vitamin C was 494.51 and 1201.40 mg/100 g d.b., respectively, while its value in the fried sample was 443.65 mg/100 g d.b. The highest loss of vitamin C was observed after frying treatment (65.75%), while the lowest loss was recorded in the sample roasting on the hob (7.26%), in relation to the initial amount in unprocessed pepper. Also, the results of vitamin C content indicate that its loss was higher when the thermal treatment was performed in an opened than in the closed dish probably due to the increased presence of oxygen that may intensify oxidation. However, the obtained quantity of vitamin C per mg/100 dry basis of the tested samples is more than enough to ensure daily intake of vitamin C and avoid its deficiency in the human diet.

Key words: Vitamin C, Pepper, Cooking, Roasting, Frying.

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T2-P-5 Medicinal and aromatic herbs as functional ingredients for specialty beverages

Saša Despotović, Dragana Paunović, Jovana Marković, Viktor Nedović[12],
Sofija Djordjević[13],
Sonja Veljović[14],
Aleksandra Martinović[15]

KEYWORDS: medicinal herbs; aromatic herbs; ingredients; beverages.

INTRODUCTION:

The quest for foods that have a health-promoting impact began many years ago as a functional food. Nowadays, the varieties of food products and food ingredients are more about how they impact the health and well-being of consumers. Throughout history, herbs have been used to add taste and/or preservation to foods. The creative use of herbs can make food much more enjoyable, and not less healthy. Various herbal infusions can be added to beverage compositions to increase nutritional qualities and health benefits while maintaining a sensory and pleasant balance throughout the fortification process.

OBJECTIVES:

The primary objective of the study was to develop and manufacture specialty drinks made from fruit juices and extracts of medicinal and aromatic plants that had a high concentration of biologically active chemicals and a high antioxidant activity. Three types of soft drinks have been developed: those with potentially targeted physiologically beneficial effects on metabolism, cardiovascular system, and body resistance, as well as those with medicinal and aromatic herbs whose positive healing effects have already been documented in previous research.

METHOD / DESIGN:

Fruit juices were made by mechanically processing mature fruits, that have not been fermented and have been preserved only via physical methods. The plant material was dried in ambient conditions and ground shortly before extraction. A single percolation method was used to create liquid plant extracts. Extracts of medicinal and aromatic herbs were mixed in combinations with specific functional characteristics sensory acceptable and compatible with fruit blends. Total flavonoid content, polyphenols, and antioxidant capacity were determined.

RESULTS:

Plant extracts and fruit juices were first classified in terms of total phenols, and their antioxidant activity was assessed using the FRAP and DPPH tests. The total antioxidant activity determined by the FRAP assay and the antioxidant activity determined by the DPPH test were correlated with the total phenol content. The number of phenolic compounds in tested herbal extracts and fruit juices differs significantly at the level of statistical significance of p 0.05. Given that antioxidant activity is directly proportional to phenolic component concentration, the FRAP and DPPH test both demonstrated statistically significant antioxidant activity.

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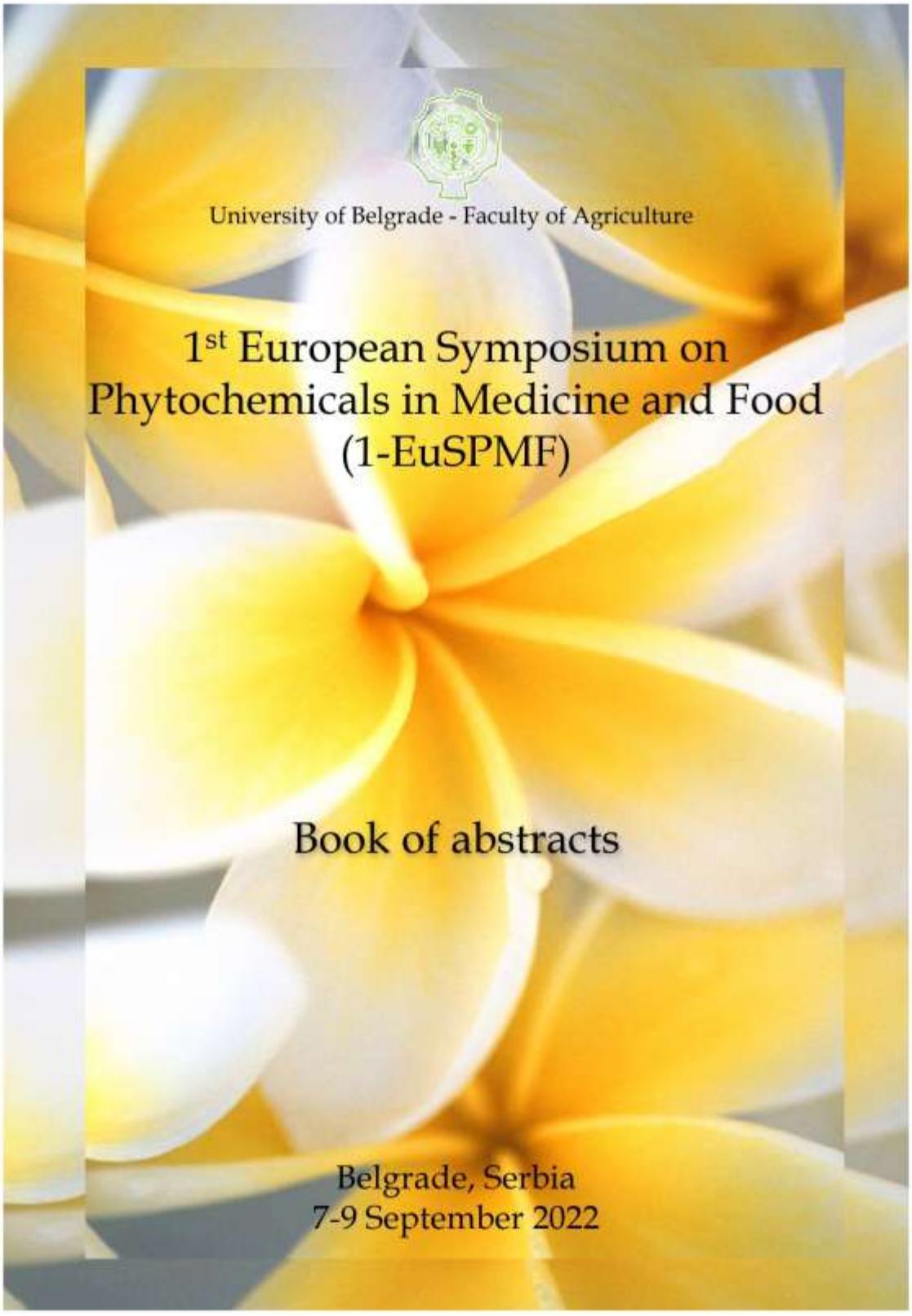
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VII_PP1_Effect of different heat treatments on antioxidative activity in pumpkin (*Cucurbita maxima*)

Jovana Marković[1], Dragana Mihajlović[1], Pavle Mašković[2], Nebojša Banjac[1], Jelena Mašković[2], Evica Ivanović[1]

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Pumpkin (*Cucurbita maxima*) contains significant amounts of diverse phytochemicals, including polyphenols (flavonoids, tannins) and carotenoids. Some of these compounds are known antioxidants, capable of neutralizing harmful biological free radicals, thus protecting health of living organisms. However, the numerous food-processing technologies decrease the amounts of naturally occurring antioxidants, due to enzymatic and nonenzymatic oxidation processes. The aim of this research was to determine the influence of different heat treatments (cooking, baking in conventional and microwave oven) on the antioxidant activity of phytochemicals present in the pumpkin.

The antioxidant activity was quantified spectrophotometrically, at the specific wavelengths, utilizing standard colorimetric reactions. The total antioxidant capacity of the analyzed samples was determined by phosphomolybdate method using ascorbic acid as a standard [1]. Antioxidant activity was measured by the inhibition of lipid peroxidation (FTC) [2] and free radical scavenging (DPPH[•] [3], hydroxyl [4] and ABTS radical cation [5]) methods.

The highest total antioxidant capacity was found in a raw pumpkin sample (5.58±0.33 mg AAE/g), while the lowest value was found in a sample of pumpkin baked in conventional oven (2.88±0.32 mg AAE/g). Inhibition activity against lipid peroxidation (IC_{50}) was the highest in raw pumpkin (16.72±0.73 μg/ml), and the lowest one was in conventional baked pumpkin (8.49±0.31 μg/ml). Free radical scavenging activity measured by DPPH and hydroxyl radicals (IC_{50}) were the highest in raw sample (35.67±1.99 μg/ml) and (19.46±1.60 μg/ml), respectively, while the lowest values were in conventional baked pumpkin (15.68±1.32 μg/ml) and (9.69±2.01 μg/ml), respectively. Antioxidant activity measured by ABTS radical cation scavenging (IC_{50}) was the highest in raw sample (41.63±0.61 μg/ml) and the lowest value was found in a sample baked in conventional oven (21.32±0.45 μg/ml). The results showed that different heat treatments significantly affected on antioxidant activity, especially baking in conventional way, what makes it the least favorable process in this study.

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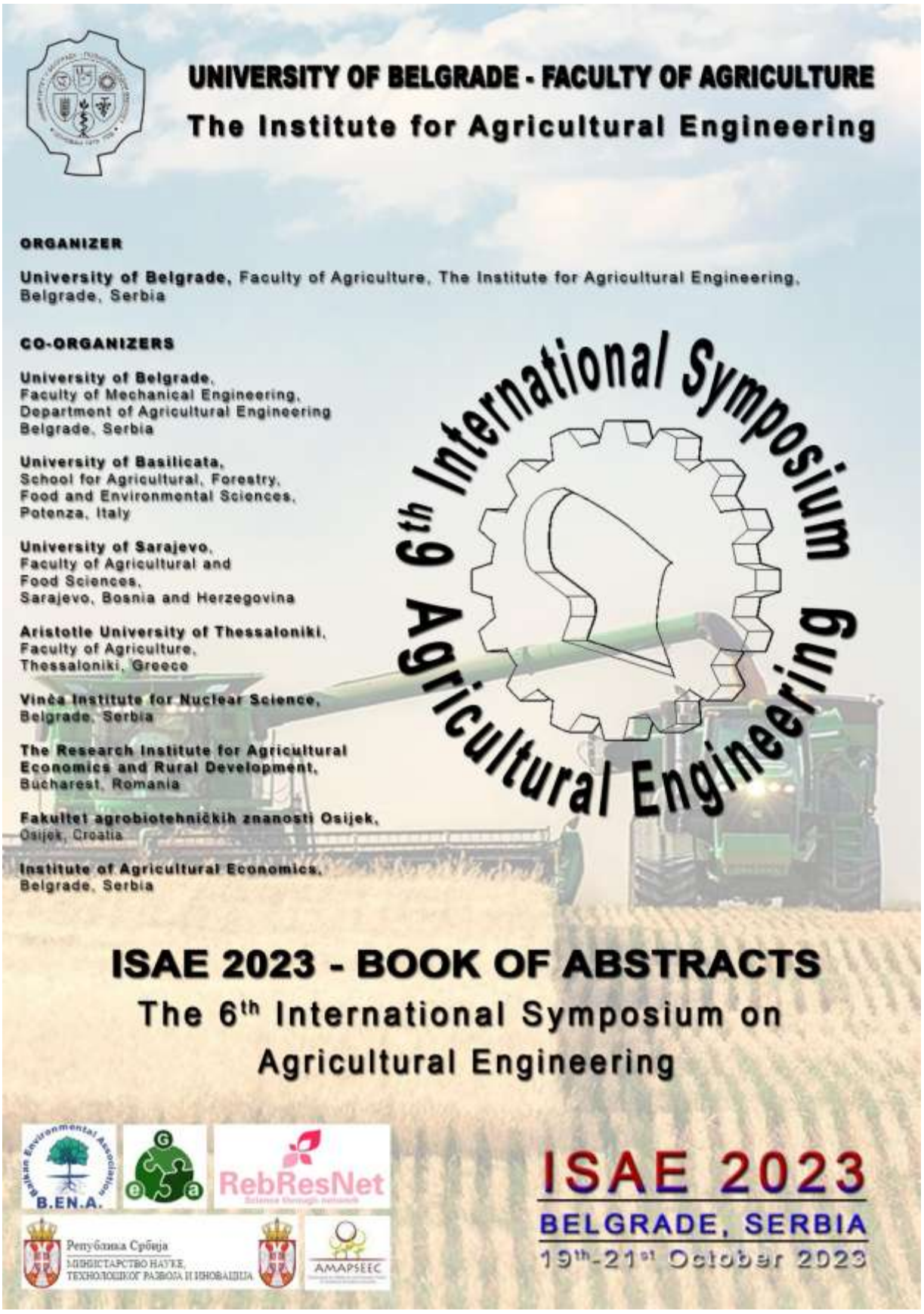
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THE POSSIBILITY OF USING HORSERADISH LEAVES POMACE IN THE FOOD INDUSTRY

Marković M. Jovana*, Nedović A. Viktor, Salević-Jelić S. Ana, Pejić D. Lazar, Mihajlović M. Dragana

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Abstract: Horseradish is a plant that belongs to the Brassicaceae family and is native to southeastern Europe and western Asia. It is cultivated for its succulent and spicy root, which is used as a seasoning for meat, soups, seafood, etc. The horseradish root has a much higher culinary value than the horseradish leaf, which is usually discarded with the rest of the above-ground biomass and has no use in the food industry. However, the horseradish leaf can be used in the diet in the form of salad or in the preparation of various dishes, to which it gives a characteristic spicy flavor. The biological activity of horseradish is expressed as antimicrobial, insecticidal, anticoagulant, and gastro-protective effects of isothiocyanates, compounds formed by the hydrolysis of glucosinolates under the action of the enzyme myrosinase. In addition, the horseradish leaf is rich in vitamin C, polyphenols, and flavonoids, which is why it is desirable to press it to obtain juice that can be used in the food industry. Moreover, pressing leaves behind a pomace that could also potentially be used in the food industry. Therefore, this research aimed to analyze the content of phenolic compounds and the antioxidant potential of the horseradish leaves pomace, to achieve the full utilization of the plant and reduce biomass loss. Total phenolic content (TPC), total flavonoid content (TFC), total phenolic acid content (TPAC), and antioxidant activity (DPPH, ABTS, and FRAP methods) were determined by standard spectrophotometric methods. The results showed that the quantitative content of total phenolic compounds, flavonoids, and phenolic acids in horseradish leaves pomace, after pressing and obtaining juice, was 7825.50 ± 749.20 mg GAE/kg FW (fresh weight - FW), 9460.00 ± 138.60 mg CE/ kg FW and 8905.50 ± 336.90 mg CAE/kg FW, respectively. In the analysis of antioxidant activity, it was found that all three methods indicate the presence of antioxidant potential of horseradish leaves pomace, namely: 9.00 ± 0.70 mmol TE/kg FW (DPPH), 42.30 ± 3.80 mmol TE/kg FW (ABTS) and 17.30 ± 0.60 mmol TE/kg FW (FRAP). Based on the obtained results, it can be concluded that horseradish leaves pomace contains significant amounts of polyphenolic compounds and high antioxidant potential, making it a suitable raw material for the food industry, both from the point of view of waste prevention and potential enrichment of food products to which it is added (as a seasoning for salads and dehydrated soups, etc.).

Keywords: *horseradish leaves pomace; polyphenols; phenolic acids; flavonoids; antioxidant activity.*

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ANTIOXIDANT POTENTIAL AND PHENOLICS CONTENT OF HORSERADISH ROOT JUICE ENCAPSULATED WITHIN DIFFERENT CARBOHYDRATE MATRICES

Jovana Marković[1*], Viktor Nedović[1], Ana Salević-Jelić[1], Steva Lević[1], Verica Đorđević[2], Spasoje Bošević[1], Dragana Mihajlović[1]

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Horseradish is a plant grown for its succulent and spicy root, which presents a rich source of antioxidants such as phenolic compounds, vitamin C, and isothiocyanates. Due to its antioxidant properties, cold-pressed horseradish root juice could be an active ingredient in functional foods. However, fresh juices undergo enzymatic and microbiological changes, so it is necessary to preserve them. One of the approaches commonly used for this purpose is encapsulation by spray-drying, which involves the entrapping of bioactive components within carrier agents. This ensures the protection of the bioactive component from undesirable external factors and its controlled release. Many studies have shown that the use of a combination of maltodextrin and hydrocolloids as encapsulation carriers results in high-quality encapsulates. So, the aim of this study was the encapsulation of horseradish root juice and the characterization of the obtained encapsulates as potential antioxidants in food production.

Maltodextrin/guar gum (MD/GG) and maltodextrin/gum Arabic (MD/GA) were used as carriers to encapsulate horseradish root juice by spray-drying. Total phenolic, flavonoid, and phenolic acid contents (TPC, TFC, and TPAC, respectively) and antioxidant activity (DPPH, ABTS, and FRAP methods) were determined by standard spectrophotometric methods.

MD/GG and MD/GA with encapsulated horseradish root juice contained 1628 and 1568 mg gallic acid equivalents/100 g, respectively, of TPC; 264 and 253 mg catechin equivalents/100 g, respectively, of TFC; and 3272 and 3397 mg caffeic acid equivalents/100 g, respectively, of TPAC. Results for the antioxidant activity (expressed as mmol Trolox equivalents/100 g) of MD/GG and MD/GA were 0.8 and 0.7, respectively (DPPH); 6.9 and 7.6, respectively (ABTS); and 8.8 and 8.6, respectively (FRAP).

In conclusion, horseradish root juice encapsulated within carbohydrate biopolymers contained significant amounts of phenolic compounds and high antioxidant activity, which makes it a potential replacer for synthetic antioxidants in the food industry and opens the possibility for further research on this topic.

Key words: horseradish root juice; encapsulation; carbohydrate biopolymers; phenolics; antioxidant activity

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PHYSICOCHEMICAL CHARACTERIZATION OF SPRAY-DRIED HORSERADISH ROOT JUICE ENCAPSULATED WITHIN MALTODEXTRIN/ALGINATE

Jovana Marković[1]*, Dragana Mihajlović[1], Ana Salević-Jelić[1], Steva Lević[1], Verica Đorđević[2], Spasoje Bošević[1], Viktor Nedović[1]

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Spray-drying is one of the widely used techniques to extend the shelf-life and easier handling of vegetable juices. However, the high temperatures in the spray-drying chamber may cause the degradation of the bioactive components of the juices. Also, the enzyme activity and sugar content of fresh juices can lead to difficulties in drying and resulting in powders with unfavorable physicochemical properties. To overcome these problems, juices can be encapsulated within various biopolymers. Carbohydrates, maltodextrin, and alginate were used as carriers for the spray-drying encapsulation of bioactive components of various plant juices and extracts. To our knowledge, there are no reported studies on the encapsulation of horseradish root juice within these carriers. Therefore, this study aimed to investigate the influence of the maltodextrin/alginate carrier mixture on the physicochemical properties of the horseradish root juice preserved by the spray-drying encapsulation technique.

Root juice powder without a carrier (C, control sample) and maltodextrin/alginate encapsulates of root juice (MD/AL) were prepared by spray-drying. The powders were analyzed using standard analytical methods to determine the moisture content, water activity, hygroscopicity, oil holding capacity, bulk, and tapped density.

Moisture content, water activity, and hygroscopicity were lower in MD/AL (7.8%, 0.28, 22.9 g/100 g) than in C (10.2%, 0.32, 24.4 g/100 g). MD/AL had a higher oil holding capacity (1.4 g oil/g) compared to C (1.1 g oil/g). The values for bulk and tapped density were for MD/AL 0.5 and 0.7 g/cm^3 and C 0.6 and 0.7 g/cm^3, respectively.

Finally, the encapsulation of horseradish root juice in maltodextrin/alginate resulted in powders with significantly better physicochemical properties than spray-dried horseradish root juice without carrier. Based on this study, it can be concluded that the encapsulation process has great potential for the preservation of vegetable juices and provides many perspectives for further research and application in food products.

Keywords: spray-drying; encapsulation; maltodextrin/alginate; physicochemical characterization; horseradish root juice

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BROCCOLI MICROGREENS-APPLE JUICE AS NOVEL BEVERAGES: TOTAL PHENOLIC, FLAVONOIDS AND ANTIOXIDANT ACTIVITY

Spasoje Bešević[1]*, Danijel Milinčić[1], Ana Salević-Jelić[1], Jovana Marković[1], Steva Lević[1], Mirjana Pešić[1], Stefan Marjanović[1], Verica Đorđević[2] and Viktor Nedović[1]

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Recently, microgreens have been recognized as a potential food of the future, and their application in the formulation of new products has been scarcely investigated. Only a few studies promote the use of microgreens and sprouts in the formulation of novel products, primarily beverages. The most often cultivated, analyzed and used microgreens are from the *Brassicaceae* family, because they present a good source of bioactive compounds, primarily glucosinolates, isothiocyanates and phenolic compounds. However, products from these microgreens species have a typical flavor, with herbaceous, grassy and sulphurous notes, often repulsive to consumers. Therefore, this study aims to examine total phenolic (TPC) and flavonoids (TFC) content, as well as antioxidant properties ($ABTS^{\bullet+}$ and FRAP) of novel sensorially acceptable broccoli microgreens-apple juice (BC-AJ). Previously produced cold-pressed broccoli microgreens and apple juices were mixed in the ratios 51% and 49% respectively, and further analyzed by well-known spectrophotometric methods such as Folin-Ciocalteu's (TPC) and aluminum chloride (TFC) methods, as well as methods based on radical scavenging ($ABTS^{\bullet+}$) and ion reducing (FRAP) activities for evaluation of antioxidant properties. Results for the TPC and TFC of BC-AJ were 109.78 ± 1.08 mg GAE/100 mL and 64.68 ± 2.25 mg QE/100 mL, respectively. Furthermore, novel BC-AJ had a good ability to scavenge $ABTS^{\bullet+}$ radicals (162.90 ± 4.42 mg TE/100 mL) and a tendency to reduce $[Fe^{3+}\text{-}(TPTZ)_2]^{3+}$ complexes (258.50 ± 3.26 mg TE/100 mL), probably due to the most diverse of phenolic compounds originated from broccoli and apple. Finally, broccoli microgreens-apple juice has a high content of phenolic compounds and good antioxidant properties, so it can be considered as a potentially functional beverage, but future research that includes additional *in vitro* and *in vivo* studies is necessary.

Keywords: broccoli microgreens-apple juice; cold-pressing; total phenolic content; total flavonoid content; antioxidant activity

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CHARACTERIZATION OF AMARANTH (*AMARANTHUS TRICOLOR L.*) MICROGREENS JUICE ENCAPSULATED WITHIN INULIN AND MALTODEXTRIN

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Amaranth microgreens represent a rich source of betalains and phenolic compounds, which show a broad range of positive effects on human health. However, these biocompounds are very sensitive and easily degraded, which often limits their application and bioaccessibility. For the above reasons, natural extracts and juices are most often encapsulated using different carriers, which protect and control the release of bioactive compounds. The aim of this study was to encapsulate cold-pressed amaranth (*Amaranthus tricolor* L.) microgreens juice using maltodextrin (AMD) and inulin (AIN) as carriers and to investigate total phenolic content (TPC), total flavonoid content (TFC) and antioxidant properties (ABTS$^{\bullet+}$ and FRAP) of obtained spray-dried powders. To the best of our knowledge, this is the first report on the encapsulation of amaranth microgreens juice. Before analysis, both powders were reconstituted in Milli-Q water (5% solutions) and analyzed using well-known spectrophotometric methods. The results are expressed in mg equivalents (gallic acid, quercetin, Trolox) per 100 g encapsulates. The obtained values for TPC and TFC for AMD were 291.7 ± 3.0 mg GAE/100 g and 291.3 ± 2.5 mg QE/100 g, while values for AIN were 356.9 ± 1.0 mg GAE/100 g and 289.6 ± 3.8 mg QE/100 g. The results of antioxidant activity were as follows: 546.3 ± 12.6 mg TE/100 g (AMD) and 745.2 ± 3.1 mg TE/100 g (AIN) for ABTS$^{\bullet+}$ and 713.3 ± 8.4 mg TE/100 g (AMD) and 905.1 ± 4.5 mg TE/100 g (AIN) for FRAP. Finally, maltodextrin and inulin can be successfully used for the encapsulation of bioactive compounds of amaranth microgreens. In addition, both powders show good antioxidant properties and can be used in the food industry as potentially novel additives or supplements.

Keywords: amaranth microgreens juice; encapsulation; inulin; maltodextrin; antioxidant activity

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ENCAPSULATION OF BROCCOLI MICROGREEN JUICE: PHYTOCHEMICAL COMPOSITION AND ANTIOXIDANT ACTIVITY

***Belošević D. Spasoje*[1], *Milinčić D. Danijel*[1], *Salević-Jelić S. Ana*[1], *Marković M. Jovana*[1], *Lević M. Steva*[1], *Pešić B. Mirjana*[1], *Marjanović M. Stefan*[1], *Dorđević B. Verica*[2], *Nedović A. Viktor*[1]**

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Encapsulation is a process that implies the active compounds are enclosed in a wall material using various techniques, creating a barrier that protects the active ingredients from unfavorable environmental conditions. The most commonly encapsulated active compounds derive from plant extracts and juices. Broccoli microgreen juice as a source of active compounds for encapsulation has not been used so far. The aim of this study is the encapsulation of broccoli microgreen juice (BCJ) in maltodextrin as wall material by spray drying technique and the characterization of the obtained powder in terms of phytochemical composition and antioxidant activity. The spectrophotometric assays were used to determine the content of total phenolics (TPC), flavonoids (TFC) and antioxidant activity (AA) ($ABTS^{\cdot+}$, $DPPH^{\cdot}$ and FRAP). The TPC, TFC, and AA were expressed in mg equivalents (gallic acid, quercetin, and Trolox, respectively) per 100 g of the encapsulates. The values determined for TPC were higher than those for TFC. Regarding antioxidant activity, the results followed the order FRAP>$ABTS^{\cdot+}$> $DPPH^{\cdot}$. It should be noted that the antioxidant potential expressed by the encapsulated BCJ varied due to different mechanisms of the employed antioxidant assays. In summary, broccoli microgreen juice encapsulated in maltodextrin showed a high content of phenolic compounds and good antioxidant activity and can be defined as a novel food ingredient. In addition, future studies should focus on the addition of encapsulated broccoli microgreen juice in food products and the characterization of such products.

Keywords: encapsulation; spray drying; microgreen juice; phytochemical composition; antioxidant activity

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ENCAPSULATED HORSERADISH LEAF JUICE: A POTENTIAL ALTERNATIVE TO SYNTHETIC ANTIOXIDANTS IN MAYONNAISE PRODUCTION

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Horseradish leaf is an under-researched source of phenolics with pronounced antioxidant potential. Due to the high biological activity of fresh horseradish juices, it is desirable to encapsulate them by spray-drying, a cost-effective one-step process suitable for scaling up production. The potentially harmful effects of synthetic antioxidants have led to an increasing demand for antioxidants from natural sources to maintain the oxidative stability of lipid-rich products. Therefore, this study aimed to compare the effect of encapsulated, spray-dried horseradish leaf juice within maltodextrin/alginate (MD/AL) and maltodextrin/gum Arabic (MD/GA) with the effect of a conventionally used synthetic antioxidant ethylenediaminetetraacetic acid (EDTA) on the mayonnaise oxidative stability, quality, and sensory properties.

Sunflower oil (75%), egg yolk (3%), vinegar (3%), sugar (3%), and salt (1%) were used for mayonnaise production. The water content (15%) was reduced by adding encapsulates (in an amount to achieve a total phenolic content of 400 mg gallic acid equivalents/kg mayonnaise). The mayonnaise containing EDTA was used as a positive control. Based on an accelerated oxidative stability test, MD/AL and MD/GA were found to be more effective than EDTA in delaying the mayonnaise oxidation, by prolonging the induction period (by 39 and 32%, respectively). The mayonnaise quality during the eight-week storage period was determined by measuring the pH and acid values. The horseradish encapsulates also improved the product quality with a higher pH (by 0.5-1.5%) and lower acidity (by 21.4%) after storage compared to the positive control. A nine-point hedonic scale was used for the sensory analysis of the mayonnaises. The overall acceptability of the mayonnaises followed the order: MD/AL>EDTA>MD/GA, with scores above 7 ("like moderately").

Finally, horseradish leaf juice encapsulates positively affected the oxidative stability, quality, and sensory properties of the mayonnaise, indicating the great potential of these natural antioxidants as a substitute for synthetic ones in the food industry.

Keywords: horseradish leaf juice, encapsulation, antioxidant activity, mayonnaise, oxidative stability

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THE INFLUENCE OF CARBOHYDRATE CARRIERS ON THE MORPHOLOGY AND PHYSICAL PROPERTIES OF RED BEET MICROGREEN JUICE ENCAPSULATES

***Belošević D. Spasoje*[1], *Milinčić D. Danijel*[1], *Salević-Jelić S. Ana*[1], *Marković M. Jovana*[1], *Pavlović B. Vladimir*[1], *Lević M. Steva*[1], *Pešić B. Mirjana*[1], *Marjanović M. Stefan*[1], *Đorđević B. Verica* [2], *Nedović A. Viktor*[1*]**

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Red beet microgreen juice is considered a novel functional beverage due to its content of bioactive compounds, including the color pigment betalain and flavonoids. Considering the sensitivity of these bioactive compounds, it is necessary to protect them by encapsulation within carriers to extend their shelf life. The aim of this study was to apply the spray drying technique for the encapsulation of red beet microgreen juice in inulin (RIN) and maltodextrin (RMD) carriers and to determine the effects of spray drying on the morphology and physical properties of obtained encapsulates. The morphological properties of the obtained encapsulates were examined by scanning electron microscopy (SEM), while the moisture content, tapped and bulk density and color were determined by standard methods. The RMD was characterized by a small particle size with the presence of typical spherical particles and pseudo-spherical particles with irregular surfaces due to rapid evaporation at high temperatures in the spray drying chamber. In contrast to RMD, RIN had larger particles with a high degree of agglomeration as inulin is a larger molecule and more hygroscopic than maltodextrin. The moisture content of the encapsulates was below 10 %, with the higher bulk density of RIN compared to RMD. Regarding the color of the encapsulates, those in maltodextrin showed a higher brightness and saturation than the encapsulates within inulin. In summary, inulin and maltodextrin provide good morphological and physical properties and can be used for the encapsulation of red beet microgreen juice. However, further studies should include a detailed phytochemical characterization of the encapsulates.

Keywords: red beet microgreen juice, inulin, maltodextrin, scanning electron microscopy, moisture content

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HORSERADISH LEAF JUICE ENCAPSULATES: PHYSICOCHEMICAL, SPECTROPHOTOMETRIC, AND CHROMATOGRAPHIC CHARACTERIZATION

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Horseradish is mainly used in the food industry for its succulent and spicy roots, while the horseradish leaves are usually disposed of with the above-ground biomass. The cold pressing of horseradish leaves produces a juice that is rich in bioactive compounds with pronounced antioxidant potential. However, due to its high water content and biochemical reactivity, it is prone to degradation. The bioactive compounds of horseradish leaf could be protected from undesirable external factors by spray drying encapsulation within maltodextrin/alginate (MD/AL) and maltodextrin/gum Arabic (MD/GA) carriers. Therefore, the aim of this study was to encapsulate horseradish leaf juice within these carriers and to evaluate the physicochemical, spectrophotometric, and chromatographic properties of the obtained encapsulates. Using standard analytical methods, lower values for moisture content, water activity, solubility, oil holding capacity, and encapsulation yield were obtained for MD/AL than for MD/GA encapsulates. Standard spectrophotometric methods were used to characterize MD/AL and MD/GA encapsulates in terms of total phenolic content (5241.25 and 4849.00 mg gallic acid equivalents/100 g), total flavonoid content (4640.67 and 4159.99 mg catechin equivalents/100 g), total phenolic acid content (5008.34 and 7013.20 mg caffeic acid equivalents/100 g), and antioxidant activity (mmol Trolox equivalents/100 g: 0.88 and 0.44 (DPPH); 58.67 and 63.20 (ABTS); and 15.78 and 13.71 (FRAP), respectively). Using an ultra-high-performance liquid chromatography system, coupled with a quadrupole time-of-flight mass spectrometry, a total of fourteen phenolic compounds were quantified after extraction from the encapsulates. The chromatographic analysis also confirmed the higher total content of all identified phenolic compounds in MD/AL (1896.87 mg/kg) than in MD/GA (1761.27 mg/kg). The obtained results highlight encapsulated horseradish leaf juice as an underestimated and underexplored source of phenolic compounds with high antioxidant potential, whose application in the food industry could valorize crop side streams and reduce synthetic antioxidant usage.

Keywords: horseradish leaf, encapsulation, spray drying, phenolic compounds, antioxidant activity

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FREEZE-DRIED HORSERADISH LEAF POMACE AS A NOVEL VALUABLE SOURCE OF ANTIOXIDANTS

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Cold-pressed horseradish leaf juice processing results in large quantities of pomace as a by-product, which is usually disposed of as waste. However, the pomace contains various antioxidant compounds that can be recovered and potentially used in the food industry. To reduce enzymatic and microbiological activity and achieve a more favorable form for addition to food, it is preferable to dry the fresh pomace. One of the most suitable drying techniques for the preservation of bioactive compounds is freeze-drying, which is performed under mild, non-thermal conditions. Therefore, this study aimed to obtain freeze-dried horseradish leaf pomace and to investigate the physicochemical properties of this by-product along with its potential as a source of phenolic compounds by spectrophotometric and chromatographic analysis. The freeze-drying process was performed under the following conditions: at a temperature of -40 °C and a pressure of 0.12 mbar for 48 h. In addition to the significantly reduced moisture content, low values for water activity and hygroscopicity were determined for the freeze-dried horseradish leaf pomace using standard analytical methods. Spectrophotometric methods were used to characterize the ethanolic (80% v/v) pomace extract, and high values were obtained for total phenolic, flavonoid, and phenolic acid contents as well as antioxidant activity (determined by DPPH, ABTS, and FRAP methods). Using an ultra-high-performance liquid chromatography system, coupled with a quadrupole time-of-flight mass spectrometry, a total of ten phenolic compounds were quantified after extraction from the freeze-dried powder. Phenolic compounds from the classes of flavonoids and phenolic acids were detected, with the kaempferol derivatives dominating quantitatively. The obtained results highlight freeze-dried horseradish leaf pomace as an underexplored source of antioxidant compounds whose addition to food products could reduce the amount of oxidation-caused waste.

Keywords: horseradish leaf pomace, freeze-drying, phenolic compounds, antioxidant activity, waste reduction

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HORSERADISH LEAF BY-PRODUCT: A NATURAL ANTIOXIDANT IN MAYONNAISE PRODUCTION

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Due to the high biological activity of fresh horseradish leaves, it is desirable to press them to obtain juice that can be used in the food industry. In addition, a pomace rich in phenolic compounds with a pronounced antioxidant activity remains as a by-product of pressing. The potentially harmful effects of synthetic antioxidants have led to an increasing demand for antioxidants from natural sources to maintain the oxidative stability of lipid-rich products. Therefore, this study aimed to analyze the effect of adding freeze-dried horseradish leaf pomace on the mayonnaise's oxidative stability and quality during an eight-week storage period. The mayonnaises were produced using the following ingredients: sunflower oil (75%), egg yolk (3%), vinegar (3%), sugar (3%), and salt (1%). The water content (15%) was reduced by adding freeze-dried pomace (in an amount giving a total phenolic content of 400 mg gallic acid equivalents/kg mayonnaise). The control mayonnaise was prepared without adding horseradish pomace. The total oxidation value, calculated as the sum of the primary and secondary oxidation products, was higher in the control sample after eight weeks of storage than in the mayonnaise containing horseradish pomace. Based on an accelerated oxidative stability test, the horseradish pomace proved to be very effective in delaying mayonnaise oxidation by prolonging the induction period compared to the control sample. The horseradish pomace also improved the product quality with a higher pH value after storage compared to the control. In conclusion, freeze-dried horseradish leaf pomace positively affected the oxidative stability and quality of mayonnaise, indicating the great potential of this natural antioxidant as a substitute for synthetic ones in the food industry. Furthermore, this study promotes the circular economy by providing insights into the assessment valorization of horseradish leaf pomace regarded as agricultural biowaste.

Keywords: horseradish leaf pomace, freeze-drying, antioxidant activity, mayonnaise, oxidative stability

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MORPHOLOGY AND PHYSICAL PROPERTIES OF BROCCOLI MICROGREEN JUICE ENCAPSULATED WITHIN MALTODEXTRIN AND INULIN

Spasoje Bošević[1]*, Danijel Milinčić[1], Ana Salević-Jelić[1], Steva Lević[1], Jovana Marković[1], Stefan Marjanović[1], Verica Đorđević[2], Mirjana Pešić[1], Vladimir Pavlović[1], Viktor Nedović[1]*

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Encapsulation is a process that is used in a variety of industries, including the food industry. There are many reasons for using encapsulation in the food industry, such as to protect an active compound from unfavorable environmental conditions, mask undesirable sensory properties, improve the stability of the encapsulated compound, facilitate handling, and improve physicochemical properties. Broccoli microgreen juice requires an encapsulation process because it contains various bioactive compounds, including phenolic compounds and sulfur compounds, which act as antioxidants. The aim of this study was to determine the morphology and physical properties of spray-dried, non-encapsulated broccoli microgreen juice (control powder) and encapsulated broccoli microgreen juice within maltodextrin (BMD) and inulin (BIN). The bulk and tapped density, moisture content, and color of the obtained powders were determined using the standard methods, while the morphological properties were determined using scanning electron microscopy (SEM). The control powder had a higher moisture content and a lower powder yield compared to the encapsulated powders. On the other hand, the obtained encapsulated powders had a higher bulk density than the control powder without any carrier, indicating better physical properties. In contrast to the BIN powder, the BMD powder exhibited higher values for brightness (L*). In terms of morphological properties, the control powder exhibited irregular particles in the form of agglomerates, indicating the stickiness of the powder. Unlike the control powder, all obtained encapsulated powders with carriers (BMD and BIN) had no agglomerates, resulting in lower stickiness. In addition, the BMD powder had spherical particles with a concave and rough surface, while the BIN powder had a smaller particle size with an irregular shape and wrinkled surface. In summary, the obtained encapsulated powders have good morphological and physical properties and can be further investigated for application in the food industry.

Keywords: encapsulation, broccoli microgreen juice, scanning electron microscopy, bulk density, tapped density

Acknowledgements: This work was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (grant number 451-03-65/2024-03/200116).

PHYTOCHEMICAL COMPOSITION AND ANTIOXIDANT PROPERTIES OF ENCAPSULATED POWDERS OF RED BEET MICROGREEN JUICE WITHIN CARBOHYDRATE CARRIERS

Spasoje Belošević[1]*, Danijel Milinčić[1], Ana Salević-Jelić[1], Steva Lević[1], Jovana Marković[1], Stefan Marjanović[1], Verica Đorđević[2], Mirjana Pešić[1], Viktor Nedović[1]*

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Red beet microgreen juice is a rich source of bioactive compounds with health-promoting properties that are important for human diets. It may be considered a healthy beverage due to its high antioxidant activity related to phenolic content. However, these compounds are sensitive and easily degradable, while red beet juice has an unpleasant, astringent, and earthy taste. The encapsulation process has recently been successfully used to protect bioactive compounds from harmful environmental influences and to mask the unpleasant taste of juices. This study aimed to encapsulate red beet microgreen juice within maltodextrin and inulin using spray-drying and to characterize the obtained encapsulates in terms of phenolic compounds and antioxidant properties. Total phenolic content (TPC) and antioxidant activity (AA) ($ABTS^{+\bullet}$ and FRAP) were determined by spectrophotometric methods, and phenolic compounds were assessed using an ultra-high performance liquid chromatography (UHPLC) system coupled with quadrupole time-of-flight mass spectrometry (Q-ToFMS). The TPC, AA, and phenolic compounds were expressed in mg equivalents of gallic acid, Trolox, gentisic acid, coumaric acid, and apigenin, respectively per 100 g of the encapsulates. Considering the results obtained, both encapsulates from red beet microgreen juice exhibited a high content of phenolic compounds, including various phenolic acid and apigenin derivatives, as well as good antioxidant activity. In our study, the encapsulates with inulin had a higher TPC than those with maltodextrin. There was a similar trend for antioxidant activity wherein the encapsulates with inulin showed stronger antioxidant activity determined by $ABTS^{+\bullet}$ and FRAP assays than those with maltodextrin. Concerning the results of the UHPLC Q-ToF MS analysis, several phenolic acid derivatives such as hydroxybenzoic acid, hydroxybenzoic acid hexoside, and dihydroxybenzoic acid pentoside were detected in the encapsulates, while various apigenin C-glycoside derivatives predominated among the flavonoids. In summary, the obtained encapsulates can be used as potential functional additives.

Keywords: encapsulation, spray-drying, inulin, maltodextrin, antioxidant activity, phenolics

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AQUAPONIC SYSTEM IN THE CULTIVATION OF MICROGREENS AND SPROUTS: A REVIEW

Spasoje Belošević, Stefan Marjanović, Jovana Marković, Ana Todorović, Steva Lević, Ana Salević-Jelić, Marko Stanković, Zoran Marković and Viktor Nedović

Abstract: Aquaponics is a novel system for the simultaneous cultivation of plants and fish, developed in response to the uncontrolled use of chemical fertilizers in plant production and the waste generated by aquaculture. In this closed-loop system, ammonia-rich fish waste is converted into nutrients by nitrifying bacteria, serving as fertilizer for plants, while the plants help purify water for the fish by removing waste products and excess nutrients. Through waste reduction and maximized resource efficiency, aquaponics exemplifies the circular economy in agriculture and food production. Microgreens and sprouts are young seedlings that only need a few weeks to grow in different substrates and systems. They are appreciated for their appearance, flavor, and higher concentrations of bioactive compounds compared to mature plants. Their short growing time and low nutrient requirements make them ideal for cultivation in all modern agricultural practises, including aquaponics. This review focuses on the application of aquaponics for cultivating microgreens and sprouts. So far, only one study has investigated the cultivation of microgreens in aquaponics, compared to more extensive research on hydroponics and sprouts. Growing arugula microgreens in an aquaponics system with goldfish positively impacted microgreens' growth rates, while sprout production exhibited higher levels of vitamin C, protein, and soluble sugars, as well as improved germination rates, weight, and height. Lettuce and rocket were successfully grown using trout wastewater as a nutrient source, enhancing yield and quality while promoting water efficiency and fertilizer savings compared to conventional production. The main limitation of the aquaponics system for growing small plants such as microgreens, sprouts, and baby leaves is the potential microbial contamination from the recirculating nutrient water. Overall, the aquaponics system is an emerging technology for growing microgreens with reduced use of natural resources while positively influencing growth parameters and phytochemical content.

Keywords: *Aquaponics, Circular economy, Microgreens, Plant and fish cultivation, Sprouts.*
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APPLICATION OF COLD PRESSING PROCESS TO DEVELOP POTENTIAL FUNCTIONAL AND SENSORY ACCEPTABLE RED BEET MICROGREENS-APPLE BEVERAGE: TOTAL PHENOLIC CONTENT AND ANTIOXIDANT PROPERTIES

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Abstract: Cold-pressed juices are consumed worldwide due to their beneficial effects on human health, which are related to phytochemical content. Wheatgrass sprout juice is the most popular cold-pressed juice consumed in its raw state and used to treat chronic diseases. Microgreens resemble sprouts and have a higher content of bioactive substances compared to mature plants. Recently studies have investigated the use of microgreens in some food technology processes such as cold-pressing. Moreover, cold-pressed red beet microgreens juice has a high content of phenolic compounds and betalains and good antioxidant properties. However, the specific taste of microgreen juices such as grassy, astringent and earthy taste is not generally accepted by consumers. Therefore, there is a need to obtain a sensorially acceptable healthy juice with a high content of health-promoting compounds. The aim of this study was to develop a cold-pressed red beet microgreen-apple juice and to evaluate the total phenolic content and antioxidant activity. The red beet microgreen and apple were cut and pressed in a cold-press juicer and then mixed in a ratio of 51% to 49%, respectively. The total phenolic content (TPC) and antioxidant activity were determined using the Folin-Ciocalteu's reagent and the assay based on radical cation scavenging (ABTS•+), respectively. The sensory test was evaluated with a 9-level hedonic scale. The developed red beet microgreen-apple juice showed a high TPC and a good ability to scavenge ABTS•+ radical cations. In terms of sensory evaluation by consumers, the newly developed juice showed good overall acceptance. In conclusion, red beet microgreens-apple juice has a high content of health-promoting compounds and good antioxidant activity, so it can be considered as potential functional beverage, but future research is needed, including additional in vitro studies.

Keywords: *Cold-pressing, Red beet microgreens-apple juice, Bioactive compounds content, Antioxidant activity.*
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Промена нутритивних и сензорних својстава при преради поврћа

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Поврће представља богат извор витамина, минералних материја и дијетних влакана, а легуминозе садрже и значајне количине протеина високе биолошке вредности. Конзумирањем свежег поврћа обезбеђен је унос бројних биоактивних компоненти које имају позитиван ефекат на људско здравље. Међутим, већина поврћа се мора на неки начин прерадити, с циљем повећања искористивости и сварљивости, као и добијања потребних технолошких карактеристика. При топлотној обради долази до деградације термолабилних компоненти, што у основи значи да ће се при операцијама бланширања и кувања, услед екстракције, смањити садржај хидросолубилних витамина (Ц, Б-комплекс), а да ће се при операцијама пржења смањити садржај липосолубилних витамина (А, Д, Е, К). На стабилност витамина при преради, осим температуре, утичу и pH вредност, садржај минералних материја, присуство кисеоника и дејство UV зрачења. Каротеноиди су група хемијских једињења која представљају бојене пигменте поврћа и воћа (мрква, парадајз, тиква, паприка и др). У ову групу спадају и једињења која имају провитаминску активност, од којих је најзначајнији β-каротен, провитамин витамина А. Утврђено је да се садржај укупних каротеноида у тикви, подвргнутој различитим начинима топлотне обраде, значајно смањио у односу на сирову (за 61,5 – 68,5%), а да је при операцији кувања губитак износио 7 – 10% више у односу на топлотну обраду у конвенционалној и микроталасној пећници. Током топлотне обраде поврћа дешавају се одређене промене и на дијетним влакнима. Утврђено је да се кувано поврће лакше и брже вари у односу на сирово. При кувању купуса и мрквe, лигнин и хемицелулоза остају непромењени, док се значајна промена дешава на целулози и пектину. Топлотном обрадом поврћа у влажној средини, долази до делимичне хидролизе молекула протопектина, настаје пектин, који повећава вискозитет раствора. Влакна, која су нерастворљива у води, делимично се разлажу, а последица ових промена је омекшавање плодова. Поред промене конзистенције, током прераде поврћа, одвијају се и бројне хемијске реакције ензимског и неензимског потамњивања, које доприносе промени боје, укуса и мириса производа. Према доступним литературним подацима, топлотна обрада не мора нужно да значи смањење нутријената у намирници, а самим тим и нутритивне вредности. Наиме, утврђено је да се топлотном обрадом парадајза повећава биолошка доступност ликопена, а да се након влажне топлотне обраде спанаћа повећава садржај калцијума.

Кључне речи: поврће, топлотна обрада, витамини, каротеноиди, дијетна влакна, потамњивање.

Changes of nutritional and sensory properties during vegetable processing

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Vegetables are a rich source of vitamins, mineral matter and dietary fibers, and leguminoses in addition contain significant amount of high biological value proteins. Consumption of fresh vegetables ensures the intake of numerous bioactive compounds that have benefits for human health. However, most vegetables must be processed in some way, with the aim of increasing bioavailability and digestibility, as well as obtaining the necessary technological characteristics. Thermolabile compounds degrade during heat treatment, which basically means that the content of water-soluble vitamins (C, B-complex) will be reduced during blanching and cooking operations, due to extraction, and that the content of fat-soluble vitamins (A, D, E, K) will be reduced during frying process. Besides temperature, the stability of vitamins during processing is also affected by pH value, mineral matter content, the presence of oxygen and the effect of UV radiation. Carotenoids are a group of chemical compounds that represent colored pigments of vegetables and fruits (carrots, tomatoes, pumpkins, peppers, etc.). This group also includes compounds that have provitamin activity, among which the most important is ß-carotene, the provitamin of vitamin A. It was found that the content of total carotenoids in the pumpkin, subjected to various heat treatment methods, significantly decreased in relation to unprocessed one (by 61.5 – 68.5%). Also, during the cooking the loss of carotenoids was increased (7 – 10%) in relation to baking in a conventional and microwave oven. During the heat treatment of vegetables, certain changes also occur in dietary fibers. It has been determined that cooked vegetables are easier and faster to digest than raw ones. During cooking cabbage and carrots, lignin and hemicellulose remain unchanged, while a significant change occurs in cellulose and pectin. By cooking of vegetables, partial hydrolysis of protopectin molecules occurs, resulting in the pectin formation, which increases the viscosity of the solution. The fibers, which are insoluble in water, partially decompose, resulting in the fruits softening. In addition to the change in consistency, during the vegetable processing, numerous chemical reactions of enzymatic and non-enzymatic browning occur, which contribute to the change of color, flavor and aroma of the product. According to the available literature data, heat treatment does not necessarily mean a reduction of the nutrients in food, and thus the nutritional value decrease. Namely, it was found that applied heat treatment increases the bioavailability of lycopene in tomatoes, also increases the calcium content in spinach.

Keywords: vegetable, heat treatment, vitamins, carotenoids, dietary fibers, browning.