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FACULTY OF FOOD ENGINEERING, TOURISM AND ENVIRONMENTAL PROTECTION
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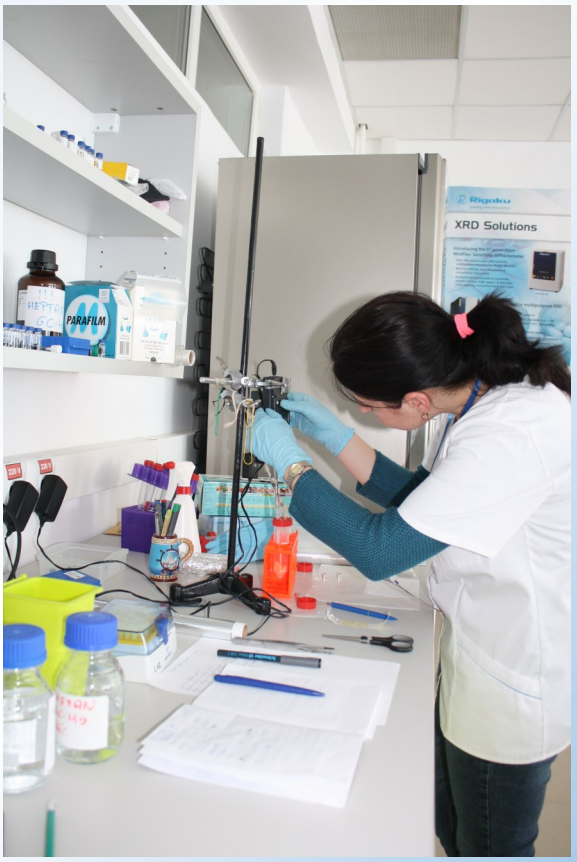

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ADDRESS
Faculty of Food Engineering, Tourism and Evironmental Protection,
„Aurel Vlaicu" University, Elena Dragoi St., Nr. 2, L31, Arad, Romania
Phone: 0040257369091
E-mail: dana.copolovici@uav.ro

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CURRENT TRENDS IN BIO-ECO-ECONOMY IN THE YOUTH DEBATE

Dana COPOLOVICI

Faculty of Food Engineering, Tourism and Environmental Protection, "Aurel Vlaicu" University, Romania, 2 Elena Dragoi, Arad 310330, Romania
**Corresponding author email: dana.copolovici@uav.ro*

Abstract: *The event titled "Current trends in bio-eco-economy in the youth debate", 1st Edition, took place on November 22nd 2019, in Arad, and was organized by Aurel Vlaicu University of Arad and Centrul Municipal de Cultura Arad. The invited lecturers proposed themes that were the subjects of debates for the participants, students and researchers from Aurel Vlaicu University of Arad and Banat's University of Agricultural Sciences and Veterinary Medicine "King Mihai I of Romania", Timişoara. Here we present the program and conclusions arisen.*

Keywords: round table, youth debate, jobs.

INTRODUCTION

An obvious and recognized fact is that young people have access to the latest scientific information on media platforms (Wikipedia, databases), including specialized ones, but they need to develop their techniques for understanding and communicating these types of information, especially the public debate, on intra- and transdisciplinary topics of biology, ecology and economics. Thus, through this project the awareness of young people will be realized for the measures to be taken, both individually and at local / national / international level for the preservation of biodiversity, environmental protection, involvement in sustainable economic processes such as: green economy, blue economy and the circular economy. Thus, we are able to experience and capitalize on this new direction of action in communication, education and health at the municipal level, but also nationally and internationally. The organization of the round table aimed to raise awareness among young people about the current challenge posed by the intense development of industry and consumerism, in particular, of the human population, worldwide, as well as how the local / national / global assessment of the Earth's resources is carried out, and the proposals, from a bio-eco-economic point of view, for maintaining its health.

THE ROUND TABLE

The round table entitled "Current trends in bio-eco-economy in the youth debate", 1st Edition, took place on November 22nd 2019, in Arad, in the building of Aurel Vlaicu University from Micalaca, Elena Dragoi Str., Nr. 2, Room 134.

At the opening of the event the welcome speech (Fig. 1a, b) was held by:

Prof.Dr. Ramona Lile, Rector of Aurel Vlaicu University of Arad;

Mr. Călin Bibarţ, Mayor of Arad city;

Mrs. Mariana Cismașiu, municipal councilor, Centrul Municipal de Cultura Arad;

Assoc.Prof.dr.ing. Ciutina Virgiliu, Dean of the Faculty of Food Engineering, Tourism and Environmental Protection;

Lect.dr. Grigorie Sanda, Dean of the Faculty of Economic Sciences;

Assoc.Prof.Dr.Eng. Lungu Monica, Director of the Department of Technical and Natural Sciences;

Prof.Dr.Habil. Dana Copolovici, project manager.

The event was organized by the Faculty of Food Engineering, Tourism and Environmental Protection and the Faculty of Economic Sciences, together with the Romanian Chemical Society, and with the City Hall of Arad, Municipal Culture Center of Arad.

The round table managed to make young participants: students, researchers from Aurel Vlaicu University and Banat's University of Agricultural Sciences and Veterinary Medicine "King Mihai I of Romania", Timișoara, Romania, aware about the current challenge posed by the intense development of industry and consumerism, product quality and processes and how to assess the local / national

situation / Earth's resources and proposals, from a bio-eco-economic point of view, for maintaining humans and environment health.

The invited lecturers and the titles of the presentations / topics of debate held in front of the participants are presented below:

Prof. Dr. Salme Timmusk, Swedish University of Agricultural Sciences, Uppsala, Sweden: "Bio-Economy, Current Trends in Global Food Security" (Fig. 1c).

Bogdan Surdea-Blaga, Country Director at Sykes Enterprises, Inc., Romania: "Digitization and future jobs" (Fig. 1d).

Ciprian Dioșan, Head of Portfolio Management Sevice at Transilvania Bank and Lecturer at the Romanian Entrepreneur Club, Romania: "Entrepreneurship and multidisciplinarity" (Fig. 1e).

Adrian Lucian Franţiu, General Manager, TÜV Rheinland, Romania: "Energetic efficiency" (Fig. 1f).

Prof. Dr. Radu Șumălan, Banat's University of Agricultural Sciences and Veterinary Medicine "King Mihai I of Romania", Timișoara, Romania: "Production of healthy foods using traditional and organic farming techniques)" (Fig. 1g).

Dr. Corina Berkesy, Senior Researcher at the Research and Design Institute for Electrical Engineering, ICPE Bistrita, Romania: "The circularity of water as a resource" (Fig. 1h).

Prof. Dr. Habil. Lucian Copolovici, Aurel Vlaicu University of Arad, Romania: "Climate change" (Fig. 1i).

Prof. Dr. Habil. Florentina Munteanu, Aurel Vlaicu University of Arad, Romania: "Valorization of solid waste for a circular bioeconomy" (Fig. 1j).

Chairman: Prof. Dr. Habil. Dana Copolovici, Aurel Vlaicu University of Arad, Romania.

The participants raised numerous questions and identified many problems and solutions to the topics discussed (Fig. 1 j,k). Due to the interdisciplinarity and transdisciplinarity of the topics debated by the invited specialists, it was suggested that this event can continue with subsequent editions, especially due to the current, new problems that appeared in the society: climate change related to crops development, unemployment of young people after graduation, ethical aspects related to new jobs, how to plan the life/business, how to become an entrepreneur, good practices in management of energy use, the production of biological crops in Romania, the efficient use of water, the influence of stress factors on plant development, pathways of valorization of solid wastes.

(a)

(b)

(c)

(d)

(e)


(f)


(g)


(h)


(i)


(j)


(k)


Figure 1. Images from the event: Current trends in bio-eco-economy in the youth debate", Round table, 1st Edition, Arad, Romania, 2019.

CONCLUSIONS

„Current trends in bio-eco-economy in the youth debate", 1st Edition, 2019, was an interdisciplinar event in which biology, ecology, chemistry, agronomy, economy, management, ethical aspects were approached in order to aware the participants about the new challenges that will be raised in the future: development of new skills and competences in order to solve the local and more widespread problems (energy and water uses, crop production, good and relible life plan, use of artificial inteligence, human happiness). This was a fruitfull event, and we hope that the next edition/s will enhance and expand communication among scientific and economic communities and our journal will provide a forum to present direction of future research and economic solutions.

ACKNOWLEDGEMENTS

The author would like to thank all the participants at the round table: „Current trends in bio-eco-economy in the youth debate", 1st Edition, 2019, for their contribution to the debate as well as to those on the audience that expressed their viewpoint through comments.

Financial support provided by Centrul Municipal de Cultura Arad, Project 6592/13.09.2019 and "Aurel Vlaicu" University of Arad, Romania, for the organization of this event is highly acknowledged.

AN EXPERIMENTAL DESIGN FOR PHENOLIC COMPOUNDS EXTRACTION FROM FLAX SEEDS

Andreea LUPITU[1,2], Nicolae DINCA[1*]

[1]Faculty of Food Engineering, Tourism and Environmental Protection, "Aurel Vlaicu" University, Romania, 2 Elena Dragoi, Arad 310330, Romania
[2]Research Development Innovation in Natural and Technical Sciences Institute, "Aurel Vlaicu" University, Romania, 2 Elena Dragoi, Arad 310330, Romania
[*]Corresponding author email: nicolae.dinca@uav.ro

Abstract: *Response surface methodology (RSM) was used to determine the optimization function for the extraction of phenolic compounds from flax seeds. Our preliminary design includes tree independent variables at two levels (8 experiments): hydrolysis temperature (60 and 80°C), extraction time (3 and 4 h) and solvent composition (ethanol/water 60:40 and 80:20 v/v). The dependent variable used in order to evaluate the extraction process of the total phenolic content of extracts obtained from flax seeds was expressed in gallic acid equivalent (mg GAE/L). Using RSM, a polynomial equation was obtained by multiple regression analysis for predicting optimization of the extraction protocol. Maximum yield was obtained when hydrolysis temperature, extraction time and solvent composition were 80°C, 4 h and 60:40 (v/v), respectively. This relation can be useful in the development and optimization of industrial extraction processes.*

Keywords: response surface methodology, optimization, flax seeds, extraction of phenolics.

INTRODUCTION

Flax (*Linum usitatissimum* L.) has been used by humans for about 10,000 years. This was probably one of the first plants that were domesticated, about 6,000 years ago BC in Mesopotamia. The uses of flax seeds can be divided into three main groups: (1) the production of oils for edible purposes (as a natural product consumed as such, for cooking, as a baking ingredient, as an ingredient in margarine products), and industrial applications agent, paint, printer ink and paints), (2) fibre production for the textile industry, and (3) use of seeds as a raw material for obtaining value-added products (food supplements high in phenolic compounds and lignans), as an ingredient in the food industry (includes bakery products, pastries and cereals for breakfast), as a functional food (to provide protection against certain types of cancer, heart disease, hyperglycaemia, stroke, and thrombosis), as animal feed, in the form of a hull resulting from seed pressing (for buffaloes, cattle, horses, poultry, cats and dogs) (Jhala and Hall, 2010; Singh et al., 2011).

Flax seeds are the most significant source of lignans (the content in lignans is up to 800 times higher than in any other food source). Other sources of phenolic compounds are: grapefruits, cherries, kiwi, plum, mandarin, olives, orange, melon, grapes, banana, tomato, pineapple (Milder et al., 2005). Lignans are a class of secondary phenolic metabolites, which have a basic structure consisting of 2,3-dibenzylbutane (Cornwell et al., 2004; Meagher and Beecher, 2000; Milder et al., 2005; Smeds et al., 2007).

The chemical composition of flax seeds varies considerably between varieties and also depends on the environmental conditions in which the plant is grown. The main components present in flax seeds are: fatty acids (α-linolenic, linoleic, oleic, palmitic and stearic acid) (Hettiarachchy et al., 1990; Oomah and Mazza, 1993); water-soluble mucilage and insoluble fibres (Warrand et al., 2005) phenolic compounds (ferulic acid, synaptic acid, coumaric acid, hydroxy-benzoic acid and caffeic acid, gallic acid, secoisolariciresinol diglucoside, pinoresinol, matairesinol, lariciresinol (Oomah, 2003; Pag et al., 2014)).

Different extraction techniques are often used to extract phenolic compounds: conventional extraction, ultrasonic assisted extraction, microwave assisted extraction, supercritical fluid extraction, and enzyme assisted extraction (Akl et al., 2017; Kim and

Mazza, 2006; Renouard et al., 2010; Westcott and Muir, 1998).

Usually, phenolic compounds are extracted from air dried, defatted flaxseeds by different solvents: methanol, ethanol, acetone, ethyl acetate, distilled water, or a mixture of them (Anwar and Przybylski, 2012; (Oomah and Mazza, 2001; Zhang et al., 2007).

The amount of phenolic compounds extracted from flax seeds can be affected by solvent polarity. The mixture of water with ethanol is often recommended to prepare extracts because of their and their safety for human consumption and handling (Kim and Mazza, 2006; Zhang et al., 2007).

The purpose of this preliminary work was to study the effect of solvent composition, hydrolysis temperature and time over the phenolic compounds extraction from flax seeds using a two-level experimental model.

MATERIALS AND METHODS

Extraction of phenolic compounds

Based on the previously reported extraction conditions (Chen et al., 2007; Popova et al., 2009; Willfor et al., 2006), an experimental design was created to find the optimal conditions for phenolic compounds extraction.

In order to obtain the crude extracts, 15 g of flax seed (Cosmin variety), milled, dried and defatted were extracted for 3 and 4 hours at 60^0C using the proportion of solvent for each sample according to the extraction protocol. The obtained extracts were hydrolysed for 2 hours using hydrochloric acid at 60-80^0C, and then neutralized and filtered.

Reagents, solvents and standards

Reagents and solvents used in the experiments were of adequate analytical grade and were obtained from Sigma Aldrich (Fluka, Switzerland), Merck (Darmstadt, Germany) and Chimreactiv (Romania).

Measurement of total phenols

Total phenolic content of the extracts obtained was determined using Folin-Ciocalteu method slightly modified (Pag et al., 2014). Briefly, the obtained extracts were diluted using distilled water (1:25). 0.5 mL Folin-Ciocalteu reagent, 2 mL Na_2CO_3 (20%) and 5 mL distilled water were added to 1 mL sample. The mixture was kept in the dark for 90 minutes. The absorbance was measured against a blank prepared in the same conditions, at 765 nm, using a UV-VIS double beam spectrophotometer (Specord 200, Analytik Jena Inc., Jena, Germany). Gallic acid was used as reference. A calibration curve for gallic acid was obtained (20, 40, 100, 160, 200 mg/L), then the regression equation and the correlation coefficient were calculated and the results were expressed in mg GAE/L. All experiments were performed in triplicates.

Experimental design

An experimental design, with three variables X_1 (solvent composition), X_2 (extraction time) and X_3 (hydrolysis temperature), at two variation levels (Table 1), was used to study the effect in the extraction process. Experiments were randomized in order to maximise the effects of unexplained variability in the observed responses due to extraneous factors (Myers & Montgomery, 2002).

Table 1 Independent variable values of the process and their corresponding levels

Independent variable		Level	
	x_i	-1	1
Solvent composition (ethanol: water, *v/v*)	X_1	60:40	80:20
Extraction time (h)	X_2	3	4
Hydrolysis temperature (^{o}C)	X_3	60	80

Data analysis

The multiple regression procedure and analysis of variance (ANOVA) from MS Excel 2016 software were used (Home Page of Excel 2016). The codified and experimental data (Table 2) were fitted to a polynomial model and regression coefficients were obtained. The generalized polynomial model used for establishing the importance and interaction of the studied factors was as follows:

$$Yi=\beta_0+\beta_1x_1+\beta_2x_2+\beta_3x_3+\beta_12x_1x_2 +\beta_{13}x_1x_3+\beta_{23}x_2x_3 \quad (1)$$

where Yi is predicted response, β_0 is offset term, β_1, β_2 *and* β_3 is linear effect terms, and β_{12}, β_{13} and β_{23} are interaction effects.

RESULTS AND DISCUSSIONS

Fitting the model

The multiple regression equation obtained with MS Excel 2016 is an empirical relationship between total phenols yield and the three factors in coded units. The significance of each coefficient was appreciated using the *Student t* test and *p-value* calculated at 95% confidence interval. The corresponding variables will be more significant if the absolute *t* value is larger or the *p-value* is smaller (Home Page of NIST/SEMATECH, 2013). Consequently, the significance of the factors decreases in the order $x_1>x_3>x_2$ and the interaction between them in the order $x_1x_3> x_1x_2>x_2x_3$ (Table 3). The minus sign of the coefficient indicates an inverse action of factor on the phenol's extraction yield. The action of the factor is stronger if the absolute value of its coefficient is greater.

Table 2. The experimental design with three variables, the observed responses, and predicted values for protein yield

	Variable levels			Experimental	Predicted
Treat	x_1	x_2	x_3	Yi	Yi
1	-1	-1	-1	878.9	887.8
2	1	-1	-1	216.8	223.9
3	-1	1	-1	921.4	912.5
4	1	1	-1	206.3	199.2
5	-1	-1	1	1069.1	1079.8
6	1	-1	1	240.8	253.3
7	-1	1	1	1115.2	1104.5
8	1	1	1	241.1	228.6

Table 3 Significance of regression coefficient for predicted total phenols content yield

Coefficients		*t Stat*	*P-value*
β_0	611.202	679.136	0.00094
β_1	-384.961	-427.749	0.00149
β_3	55.350	61.502	0.01035
β_{13}	-40.659	-45.179	0.01409
β_{12}	-12.366	-13.740	0.04625
β_2	9.808	10.898	0.05825
β_{23}	1.781	1.9787	0.29790

The interaction of x_2 with x_3 is weak so the term $1.781x_2x_3$ and $9.808x_2$ can be neglected. The equation becomes:

$$Yi = 611.20 - 384.96x_1 + 55.350x_3 - 12.366x_1x_2 - 40.659x_1x_3 \quad (2)$$

The verification of this relation was initially done by comparing the experimental values with the predicted value. The agreement of these values is also illustrated graphically (Fig. 1) and by the high value of the correlation coefficient squared (0.9993). It also indicates that most of the variation of the response data is explained by the different input values.

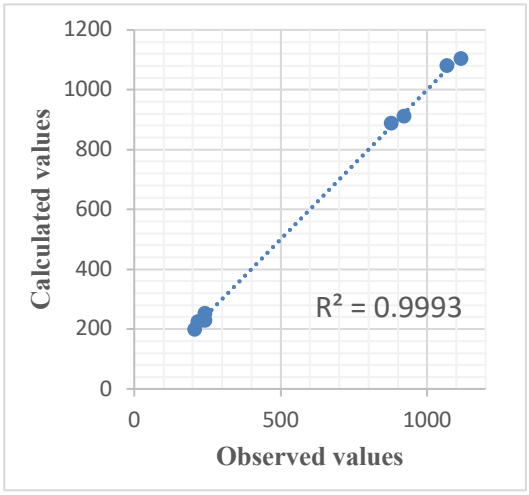

Fig. 1 Comparison between predicted and observed extraction yield.

Analysis of response surfaces

The relationship between independent and dependent variables is illustrated in three-dimensional representation of the response surfaces generated by the models for total phenols content yield.

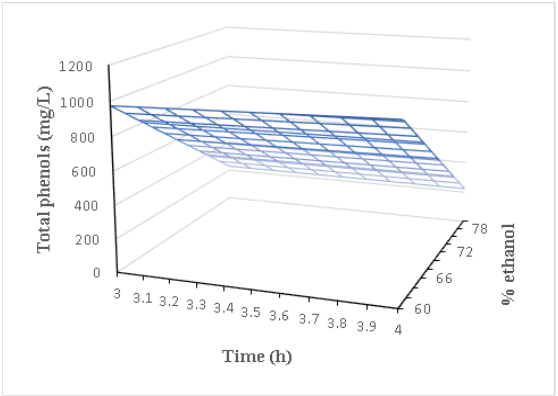

Fig. 2 Response surface plot showing the effect of extraction time and ethanol concentration at a constant hydrolysis temperature course of 70°C on total phenolic content.

The graphs in Fig. 2 and 4 show a very weak influence of the extraction time between 3 and 4 h. The largest slope of the surface is due to the percentage of ethanol in the extraction solvent (Figs. 2 and 3). This is the most influential factor of the process in the studied intervals.

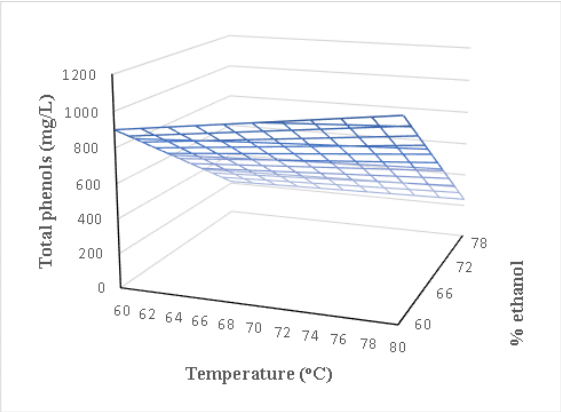

Fig.3 Response surface plot showing the effect of hydrolysis temperature and ethanol concentration at a constant extraction time course of 3.5 h on total phenolic extract.

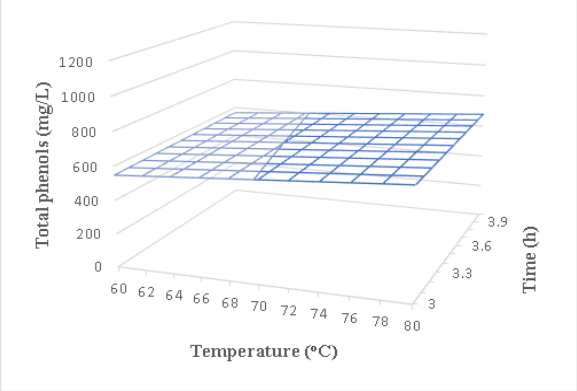

Fig.4 Response surface plot showing the effect of hydrolysis temperature and extraction time at a constant solvent composition course of 70% ethanol on total phenolic yield.

The coordinates of the highest points on the surfaces correspond to the values of the factors that ensure the maximum extraction yield (total phenols, 1114 ± 4 mg GAE/L): solvent composition (X_1, 60% ethanol), extraction time (X_2, 4 h) and hydrolysis temperature (X_3, 80°C) in the studied intervals. It is necessary in the following studies to investigate the time interval of the extraction before the low influence level between 3 and 4 h. It could thus be established how much time can be reduced without the extraction yield being substantially affected. Also, a new experimental design on three levels would highlight the curvature of the response surfaces allowing a more precise assembly of the physical-chemical optimization equations with those of economic optimization.

CONCLUSIONS

The response surface methodology was successfully employed to optimize the extraction of phenolic compounds from flax seeds. The influence of the three factors studied decreases in order: solvent ratio ethanol > hydrolysis temperature > extraction time. The resulted polynomial model gave a satisfactory description of the experimental data and allows the physico-chemical optimization of conditions for maximum extraction of total phenols. This relation can be useful in the development of industrial extraction processes.

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SMARTPHONES – SMART EATING?

Roxana-Mariana BEIU[1] and Dana Gina RADU[1]

[1]Faculty of Food Engineering, Tourism and Environmental Protection
"Aurel Vlaicu" University of Arad, 2-4 Elena Dragoi Str., Arad 310330, Romania
roxana.beiu@uav.ro

Abstract: *Currently, all around us, smartphones have become ubiquitous. One obvious question is if and how such devices could help us get healthier eating habits? The answer, based on novel technologies (e.g., advanced sensing and signal processing), is that smartphones or tablets can very easily help us check not only food quantity intake, but also food quality (e.g., freshness, chemical compounds, etc.). In this paper we will briefly survey various techniques allowing us to analyse food quality using these devices. We will start by firstly enumerating the main components of mobile cameras and sensors. Afterwards, we will briefly review nutrition analysis software. Towards the end, we will stress the importance high-performance image recognition techniques play for reaching a compelling answer to our question if we are eating smart or not yet?*

Keywords: Smartphones, Food analysis, Nutrition applications.

INTRODUCTION

Clearly, food is an absolutely essential element for life, while lately people have started to pay special attention not only to quantity (how many calories are we supposed to eat daily to have and maintain a healthy weight/diet), but also quality (new and various food storage and processing methods raise questions pertaining to their advantages and disadvantages for our health).

Today, technologies play a key role in our everyday lives as we are relying on plenty of new and smart devices. It was estimated in 2020 that worldwide there are around 3.5 billion smartphones and 1.6 billion tablets, and that these numbers are only going to follow an increasing trend [Home page of BankMyCell].

An informal definition is that a smartphone is *"a mobile phone with highly advanced features."* The main characteristics of a smartphone are: high-resolution touch screen display, WiFi connectivity, web browsing capabilities, and the ability to run sophisticated applications. The majority of applications can run on different mobile operating systems (OS) like: Android, Symbian, iOS, BlackBerry and/or Windows [Home page of Technopedia].

One aspect of interest is that researchers have already determined various ways through which food compounds could be identified by using smartphones [Kawano et al. 2015; Akpa et al. 2017; Hernandez et al. 2017]. Lately, two approaches have gained traction (see Fig. 1):

- directly imaging a food plate (Fig. 1, right), using either ambient or the flash camera light [Gordon et al. 2019];
- relying on an external dedicated device (Fig. 1, left) [Home Page of SCIO Consumer Physics, Home page of Spectral Engines].

In this paper we will first of all focus on camera lenses and the associated electronics. Afterwards, we will discuss different food analyses applications. In the end we will review the major advantages and limitations offered by smart devices for food analysis.

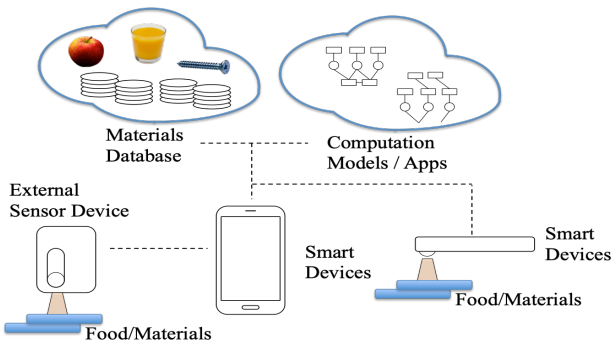

Fig. 1. Two general imaging schemes using smart phones for acquisition and data processing.

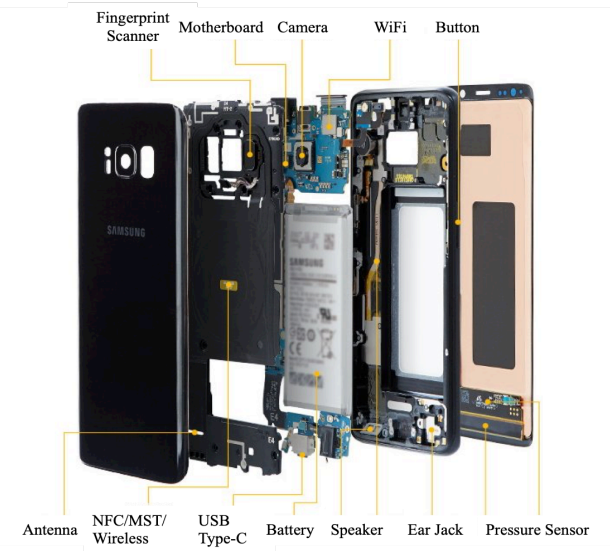

Fig. 2. Samsung Galaxy main components [Home page of Samsung]

MOBILE PHONE DEVICES

The components of a generic smartphone are: motherboard, display, camera, sensors, as well as battery (Fig. 2). The camera is a module for taking images/frames using a photographic objective. There are three main types of photographic objective: fixed focus, autofocus (AF), and optical zoom. Fig. 3 shows the most important parts of a camera: AF motor, optical system, and image sensor.

All optical systems have aberrations [Steinich et al. 2012; Chen et al. 2016], which can be classified into:

- monochromatic (e.g., spherical, coma, astigmatism, field curvature);
- chromatic – spherical and coma aberrations (as light of different wavelengths generates different focal points).

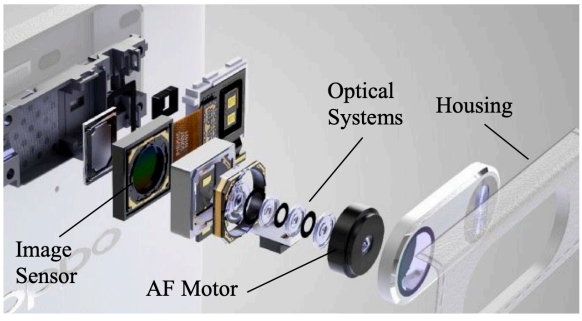

Fig. 3. OppoN3 camera main components [Home page of Oppo-N3]

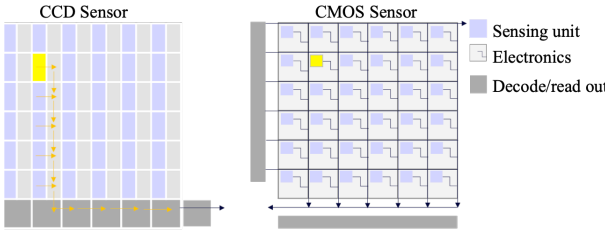

Fig. 4. Comparison of the photo sensing area sizes for a CCD vs. CMOS sensor.

By carefully crafting optical systems (and the associated image processing software packages) designers can reduce, or even eliminate, some of these aberrations [Liu et al. 2017; Zhao et al. 2019]. In fact, over the years, the lens designs have evolved starting from the simple double Gauss lens to multiple aspheric lens elements. The latest versions of smartphone cameras customary incorporate plenty of aberration corrections needed for (ultra) high quality images [Peltoketo et al. 2016; Gordon et al. 2019], as well as software for compressing and transferring them for further post-processing.

IMAGE SENSOR

Another very important component of a camera is the image sensor (Fig. 4). There are two types:

- charge-coupled device (CCD); and
- complementary metal-oxide semiconductor (CMOS) [A Konika Company, 2019].

From Fig. 4 it can be seen that the sensing area is larger for CCD than for CMOS sensors. As a consequence (see comparison in Table 1) the power consumption is quite different: a CCD sensor consumes as much as 100 × more than a CMOS one [Cevik et al. 2015].

Obviously, people are mainly interested by image resolution (total number of pixels). As can be seen from Fig. 5, the number of pixels has been exponentially growing over the years. This aspect is of major importance from the image analysis point of view, as more pixels (more information) lead to much sharper understandings but are computationally

Table 1. CCD vs CMOS sensors

	CCD	CMOS
Noise	Low	High
Light sensitivity	High	Low
Power consumption	High	Low
Price	Expensive	Cheap

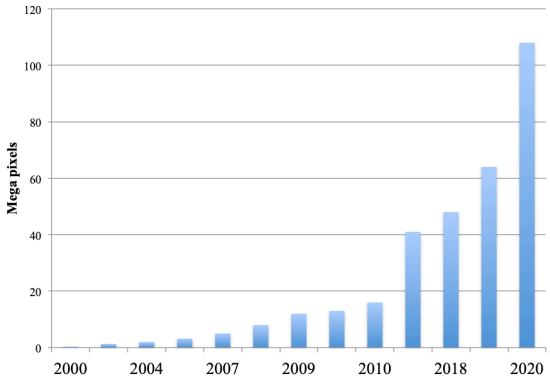

Fig. 5. Number of pixels on phone image sensors.

demanding. By incorporating additional light sources (like, e.g., IR and/or UV) [Wilkes et al. 2016; Kheireddine et al. 2019], or by connecting to external dedicated devices [Home page of SCIO, Home page of Spectral Engines] and specific apps, a smartphone could eventually behave like a lab-on-a-chip. Relying on a high quality image (of the food under test), not only optically but also properly processed digitally, one could not only store the information, but also analyse it through various software [Yetisen et al. 2014; Zhang et al. 2015; Stanco et al. 2016; Min et al. 2019] for obtaining nutrient information.

NUTRIENT ANALYSIS

A wide range of nutrition applications were developed over the last decade aiming to enable the user to describe a meal and assess its content. The majority of such applications rely on *a nutrient database* for generating *a nutrient analysis report* and compare this to the users' nutritional particular needs and special requirements. Also, most of the nutrition applications can be tailored to different needs and goals (of the end-user) providing:

- diet assessment;
- meal plans, recipe creation/selection;
- progress tracking;
- prenatal, paediatric nutrition;
- sports nutrition, etc.

The diversity and complexity of such nutrition applications expands further, with custom versions dedicated to:

- food producers and suppliers;
- food service providers;
- academics and researchers.

Such custom versions have evolved into interdisciplinary tools for product cost analysis, food labelling, recipe analysis and reformulation, new product development, instant food diary import, and goal and task management, which have to adapt to changing requirements of legislations and more. Such diversity speaks for itself for the advantages nutrient applications provide for both individual users and food related businesses (see Table 2).

Depending on the complexity, the accuracy, the quality of its data and customer service, and the degree of user-friendliness and intuitiveness, nutrition applications vary greatly in terms of costs (from freely downloadable for individual usage, to subscription based for professionals and businesses).

All of these nutrient applications can be downloaded and run on smart phones. For example, the nutrition tool MUSE Food is explained in [Gao et al. 2019]. This application can identify contours of food shapes by an improved image segmentation algorithm. In that paper, the following steps for gaining information about the food one is interested to evaluate/test are suggested:

- *sensing* by taking several images;
- *aggregation of data* which merges those images through several databases;
- *echo ranging* for estimating the food depth; and
- *segmenting* all the information gathered (using fully convolutional networks).

Table 2. Types of nutrition software applications

Online & offline applications	**Dietary analysis services**
Aliment Plus http://alimentplus.com/	Nutmeg Nutrition Consultancy http://www.nutmeg.com
Nutrition Systems Diet Sure www.dietsure.com	KelicompCRISp www.kelicomp.co.uk
Nutrition Systems CompEat Pro http://www.compeat.co.uk/	Nutricalc http://www.nutricalc.co.uk/
Nutrition Data www.nutritiondata.com	Catering for Schools www.catering4schools.com
Nutritics www.nutritics.com	Saffron https://fdhospitality.com/advice/business-challenge-nutritional-analysis/

FOOD COMPOSITION AND ENERGY VALUE

In order to be able to make informed nutritional recommendations that quantitatively and qualitatively optimise the food intake, it is necessary to match the personal energy requirements to foods which could provide it. This correlation of energy requirements with energy intake depends intimately on detailed knowledge of the amounts of macronutrients (carbohydrates, lipids, proteins). There are multiple methods for analysing macronutrients. Once those are determined, food energy conversion factors can be used to analytically make accurate estimates. Most common methods are based on:

- *Protein analysis* – Kjeldahl method to determine nitrogen content, taking into account the average nitrogen content of proteins (of about 16%);
- *Crude fat s*tudy (includes phospholipids and wax esters) – gravimetric methods (AOAC approved);
- Total carbohydrate content estimated *indirectly* (all other constituents of food – protein, fat, water, alcohol, ash – are estimated individually, summed, and finally subtracted from the food total weight to determine the carbohydrate content);
- Total carbohydrate content estimated by *direct analysis* (weight measuring);
- The *total combustible energy content* of a food can be measured using bomb calorimeters.

For expressing energy of foods, both Joules (kJ) and calories (kcal) are used by most international food standards and energy values. Stakeholders (nutrition scientists, public health professionals, policymakers, regulators, consumers, and industry) accept and support harmonization of the different food standards [Home page of Codex Alimentarius, Home page of FAO Report]. Currently, there are several food composition databases associated to a specific market which include a large portion of food products (e.g., United States Department of Agriculture USDA database).

In general, any parameter under measurments is characterized by two values: a *measurement value* and its *standard deviation.* Regarding nutrients, most often, standard deviation is zero, which means that the measurement value was provided by the producer without any testing by a third party laboratory. For food produced on a large scale (bulk products), e.g., oils, sugar, biscuits, etc., measurement values are reasonably precise (see Table 3). For unprocessed foods, e.g., raw fruits and vegetables, nutrient values are highly variable, depending on variety, degree of ripeness, agro-technical conditions, etc. [Buisson, 2008].

Table 3. Nutrient database.

Database	Web addresses
McCance & Widdowson's Composition of Foods Integrated Dataset	http://www.fao.org/uploads/media/British_FCDB_cof_user_doc.pdf
USDA database	https://fdc.nal.usda.gov/
The Swiss Food Composition Database	https://naehrwertdaten.ch/en/

In general, a higher accuracy of the measurements of nutrients can be achieved by using methods, like, e.g., mass spectrometry, infrared spectroscopy, Raman spectroscopy, or spatially offset Raman spectroscopy [Odion et al. 2019; Pino 2019]. Such methods can obviously provide very precise information on nutrients and food components, but are time-consuming, and can be performed only in specialized laboratories.

CONCLUSIONS

One worrying issue revealed by the World Health Organization pertains to the fact that the overweight and obese population has *"tripled since 1975"* [Home page of World Health Organisation; Spinelli et al. 2019]. In support of this view, the World Obesity Federation has stated that *"obesity is a chronic, relapsing, progressive disease process and emphasises the need for intermediate action and the prevention and control of this global epidemic."* It becomes clear that we should check our weight regularly [Swinburn, 2011; Nyström et al. 2017; Baumann et al. 2019].

In this paper we briefly went over methods which would allow us to detect, estimate and analyse the nutrients found in our daily food intake, methods making use of apps running on

smartphones. The interest on this topic is substantiated by:

- the development of novel sensing mechanisms [Rateni et al. 2017; Bobrinetskiy et al. 2018; Gao et al. 2019];
- an increasing number of papers being published on this topic [Ross et al. 2018; Ahn et al. 2019, Mandracchia et al. 2019];
- a larger number of companies developing software tools [Ferrara et al. 2019].

On one hand, such systems do have certain limitations: still incomplete food databases, dependence on cloud/internet, and, most importantly, low accuracy measurements of the compounds and nutrients densities [Ahn et al. 2019, Trijsburg et al. 2020].

On the other hand, latest discoveries in optics, electronics, and computer science, as well as the new IoT, should be used advantageously to improve lifestyles [Ellis et al. 2015; Ambrosini et al. 2018]. Besides making simple calls, video calls, messaging and surfing – hence using our smartphones as computers – it is compulsory that we understand and take advantage of the yet unearthed opportunities they allow, e.g., helping us adjust to smarter eating habits.

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DROUGHT STRESS INFLUENCE ON PEA PLANTS (*PISUM SATIVUM* L.)

Cristian MOISA, Dana COPOLOVICI, Andreea LUPITU, Loredana LAZAR, Lucian COPOLOVICI*

Aurel Vlaicu University, Faculty of Food Engineering, Tourism and Environmental Protection; Institute for Research, Development and Innovation in Technical and Natural Sciences, Romania, 2 Elena Dragoi St., Arad, 310330, Romania
**Corresponding author: lucian.copolovici@uav.ro*

Abstract:

Pisum sativum L. (garden peas) are highly nutritious vegetable crops destined for human consumption. Pea seeds are a valuable source of protein (23–25 %), slowly digestible starch (50 %), soluble carbohydrates (5 %), insoluble fibers, and important sources of vitamins and minerals. Apart from the genetic (variety) differences, the chemical content of pea seeds is influenced by environmental factors (cultivation area, soil composition and characteristics, trace elements and minerals, total rainfall or lack of rain, relative humidity, solarization, average temperatures, etc.).

In this study, we analyzed the drought stress on Petit Provencal, a commonly used garden pea variety in Romania. In the case of drought stress, the plants suppress stomatal opening to conserve water. During this experiment, the plant photosynthetic parameters as assimilation rate and stomatal conductance have been decreased linearly with soil water capacity. The light dependence curves of photosynthetic parameters have been shown a sharp decrease at low soil water content. The recovery parameters achieved the same values after seven days of normal watering. The polyphenols content of the seeds does not vary significantly for plants normally watered compared to those kept in drought stress

Keywords: *Pisum sativum* L., drought stress, phenolic content, photosynthesis.

Introduction

Pisum sativum L. (garden peas) are highly nutritive vegetable crops destined for human consumption widely cultivated alongside common beans. Pea seeds are a valuable source of protein (23–25 %), slowly digestible starch (50 %), soluble carbohydrates (5 %), insoluble fibers, and important sources of vitamins and minerals (Cervenski et al., 2017; Zilani et al., 2017).

Potential health-promoting properties are correlated with pea consumption, including laxative and anti-diabetic effects, alongside cardioprotective, anti-obesity, antioxidant, antifungal, antimicrobial and anti-tumor properties. Most of these health benefits are attributed to their high nutritional properties, in particular, to their chemical composition of essential amino acids (methionine, cysteine, lysine, threonine and tryptophan), carbohydrates (starches and fibers), minerals, vitamins, fatty acids (omega 9, omega 6 and omega 3), and valuable amounts of bioactive compounds such as polyphenols (Mejri et al., 2019; Nithiyanantham et al., 2012).

Almost all plants (fruits, vegetables, seeds) contain naturally occurring compounds like polyphenols, making them important sources of antioxidants with many potential health benefits (Tanase et al., 2019).

Apart from the genetic (variety) differences, the chemical content of pea seeds is influenced by environmental factors (cultivation area, soil composition and characteristics, trace elements and minerals, total rainfall or lack of rain, relative humidity, solarization, average temperatures, etc.) (Cervenski et al., 2017; Zilani et al., 2017).

Harsh weather conditions (drought) especially in the flowering and pod filling stages, have a negative influence against pea crops yields and can modify their protein and starch ratios (Baigorri et al., 1999; Cervenski et al., 2017).

Soil water content (drought) needs a few days to induce stress in plants, however, in nature drought is usually associated with high temperatures, resulting in double stress factors for the plants. During drought stress plants suppress stomatal opening in order to conserve water (Copolovici et al., 2014; Nabi et al., 2019).

The role of nutrients in plant growth is explained of their functions in plant metabolism. The nutritional status can be affected by the adaptation capacity of plants, and also the plant tolerance abiotic/biotic stresses.

This study aimed to analyze the effect of drought stress on *Pisum sativum* L. var *Petit Provencal*, a commonly used garden pea variety in Romania, regarding photosynthetic parameters, and phenolic compounds.

MATERIALS AND METHODS

Plant material

Seeds of *Pisum sativum* L. (garden peas) were sowed in commercially available soil and nursed for one month prior to analyses. The experiment was carried out in the laboratories of the Institute for Research, Development and Innovation in Technical and Natural Sciences Aurel Vlaicu University in Arad. During the experiments, the plants have been between vegetative growth stages (V3) and reproductive growth stages (R5).

Determination of photosynthetic parameters

A gas exchange device GFS-3000 (Heinz Walz GmbH, Effeltrich, Germany) as described by Copolovici et al. (Copolovici et al., 2017) was used for the analysis of the photosynthetic parameters. The established measurements conditions were: PARtop = 1000 mmol. $m^2.s^{-1}$ for the light intensity, 25˚C enclosed leaf temperature, 70% chamber relative humidity and 400 ppm CO_2 concentration. Each measurement was performed by placing a 2-3 cm^2 plant offshoot in the 8 cm^2 analysis cuvette and left until the plant was stabilized. Assimilation rate and stomatal conductance were analysed.

Chemicals and reagents

Ethanol of 96% purity was purchased from Chemical Company (Romania), and used as solvent for the preparation of the phenolic extracts. Reference standards (phenolic compounds and vitamins) were purchased from Sigma-Aldrich (Germany). Other reagents and solvents used were of analytical purity, purchased from Sigma-Aldrich and Merck (Germany).

Induction of the drought stress

In the first day, all plants were watered to field capacity. Three plants were randomly chosen for drought treatment (no water provided until soil water capacity less than 50 %), while the remaining three were watered daily. After that period, the plants have been re-watered daily (recovery). The soil water capacity (SWC) has been determined using the following formula:

SWC (%) = (mass of moist soil (g) − mass of oven-dried soil (g))/(mass of oven-dried soil (g)) × 100

Phenolic extraction method

The plant material (pea seeds) were dried at 70ºC for 72 h using the drying oven (Model FD23, Binder, Germany). All extracts were prepared using 1:10 w/v pea flour in 60% ethanol solution using static maceration for 7 days in a refrigerator at +4ºC. All extracts were shaken from time to time and in the end, filtered using 0.45 µm PTFE membrane syringe filters.

UHPLC analysis of the phenolic extracts

HPLC analyses were performed using a UHPLC (Nexera X2, Shimadzu, Tokyo, Japan) with DAD (M30A, Shimadzu, Tokyo, Japan) and a Nucleosil reversed-phase column 100-3-C18 (4.0 mm i.d. x 125 mm column length, 3 µm particle size, Macherey-Nagel GmbH, Duren, Germany). The column temperature was set at 30ºC and the flow rate was maintained 1 mL/min. The elution program and solvents are as described by Moisă et al. (2018). The references standards used were: rutin, quercetin, kaempferol, catechin, pyrogallol, pyrocatechol, p-coumaric acid, caffeic acid, vanillic acid, syringic acid, ascorbic acid, and riboflavin.

RESULTS AND DISCUSSIONS

Photosynthetic parameters

The photosynthetic parameters for *Pisum sativum* L. control plants presented high values for stomatal conductance and a net assimilation rate. After the drought begin, the photosynthetic parameters decline linearly until very low values at 60 % relative soil water content (stomata closure).

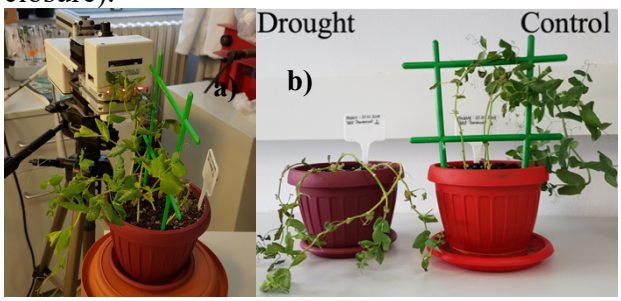

Figure 1. Monitoring photosynthetic parameters (a) and plants under stress (b) for *Pisum sativum* L. plants.

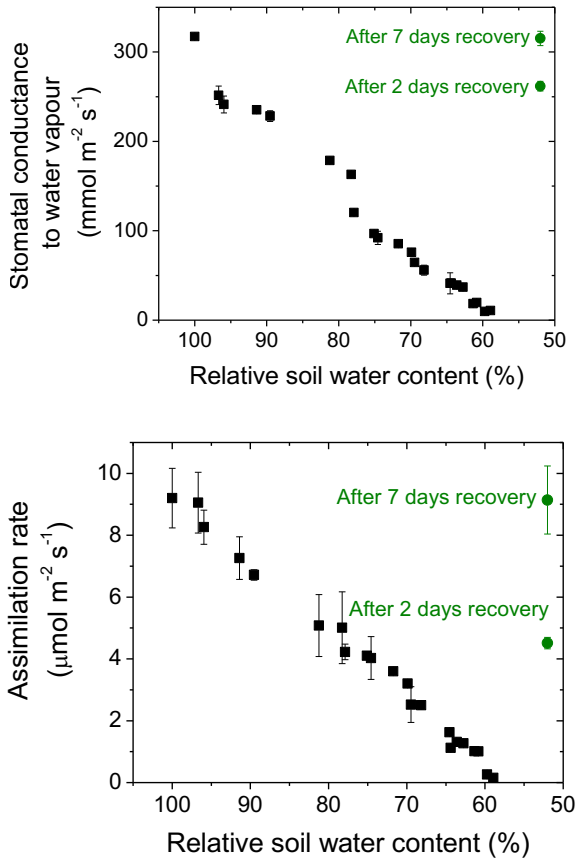

Figure 2. Stomatal conductance to water vapour and assimilation rate for *Pisum sativum* L. plants

Such behavior have been shown before for different plants species under drought stress (see (Sreeman et al., 2018) for review). After the plants have been watered, all parameters recovered at initial parameters (after 7 days). Such recovery could be due to interactions between nodule bacteria (rhizobia) which plays an important role in tolerance of *Pisum sativum* L. plants to drought (Belimov et al., 2019).

The influence of light to photosynthesis parameters

For each plant, periodic measurements were performed at different photosynthesis active radiance (0, 100, 200, 300, 400, 500, 600, 800, 1000, 1200 and 1500 µmol m^{-2} s^{-1}). The graphs obtained present the photosynthetic response of the plant to the light.

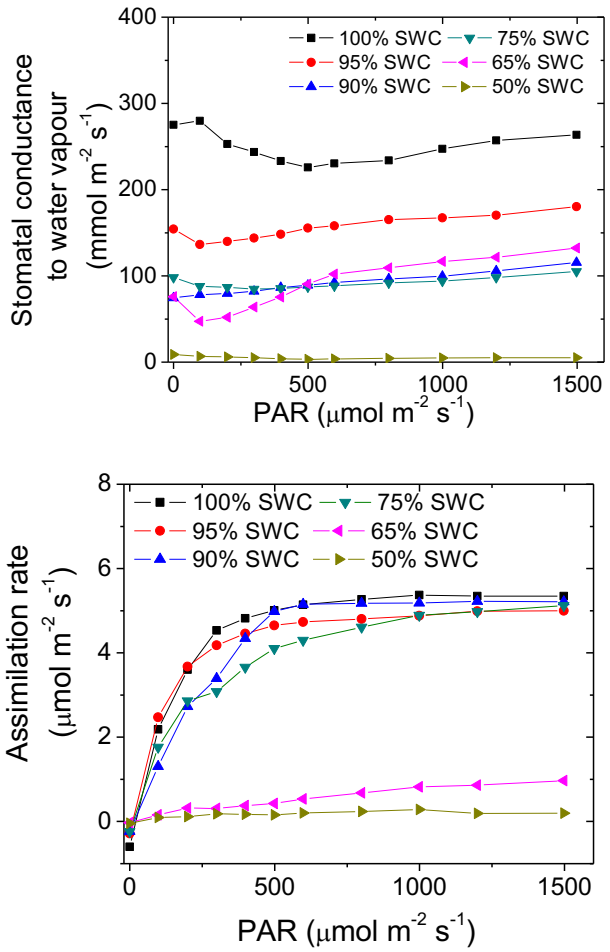

Figure 3. Light dependence of stomatal conductance to water vapour and assimilation rate for *Pisum sativum* L. plants.

The light dependence of those parameters has been shown a sharp decrease after 70 % relative soil water contents. Such behavior could be explained by a stomata closure in order to kept the water in the cells.

Phenolic composition

The extracts obtained from pea beans have significant amounts of phenolic compounds as it is presented in Table 1.

Table 1. HPLC analysis results (phenolics) of extracts from *Pisum sativum* L. seeds

Compound	Control mg/L	Drought mg/L
Riboflavin	205.86 ± 1.22	207.61 ± 7.16
Vanillic acid	2.15 ± 0.427	2.12 ± 1.053
Syringic acid	3.29 ± 0.213	2.42 ± 0.154
Catechin	0.014 ± 0.003	0.011 ± 0.002
Rutin	ND	ND
Quercetin,	ND	ND
Kaempferol	ND	ND
Pyrogallol	ND	ND
Pyrocatechol	ND	ND
Caffeic acid	ND	ND
p-Coumaric acid	ND	ND
Ascorbic acid	ND	ND

ND – not detected

The major phenolic compound in all investigated extracts was riboflavin with 207.61 mg/L, followed by syringic acid with 3.29 mg/L and vanillic acid with 2.15 mg/L, with no significant differences between control and drought plants.

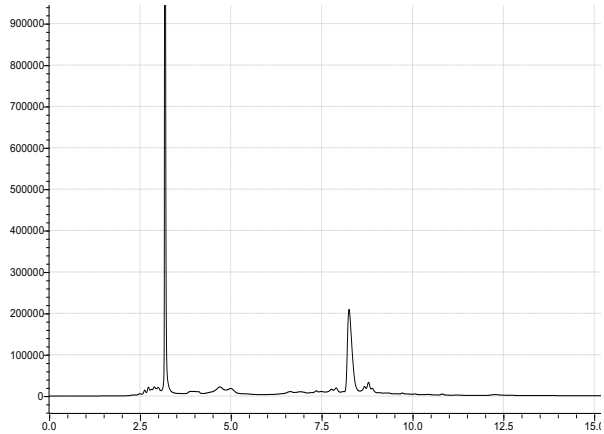

Figure 4. Example of phenolic compounds chromatogram of *Pisum sativum* L. extracts

CONCLUSIONS

Drought affects the photosynthetic parameters as assimilation rate and stomatal conductance to water vapors. The light dependence of those parameters has been shown a sharp decrease after 70 % relative soil water contents. Understanding how plants react to different environmental stressors is important for understanding climate change and its effects on food nutrition and safety.

ACKNOWLEDGEMENTS

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IMPROVEMENT OF DIDACTIC METHODS USED IN SCIENCE DOMAIN

Simona GAVRILAŞ

Faculty of Food Engineering, Tourism and Environmental Protection, "Aurel Vlaicu" University of Arad, Romania, 2 Elena Drăgoi, Arad 310330, Romania
Corresponding author email: simona2213@yahoo.com

Abstract:

One problem of modern didactics is related to application of proper scientific and efficient pedagogical methods. The didactic methods should be permanently adapted to the new generation background. In the designing process as reference point should be considered the attractiveness of the proposed technique, but without neglecting the desired outputs considered. One of the newest teaching and learning perspective suppose multidisciplinary and interdisciplinary approach of the teaching-learning process.

Classical teaching methods are principally based on teacher exposure and students individual study. Due to generation mentality changes and the inconveniences presented by the standard didactics the techniques described in the present paper are based on cooperation and discovery. The students are encouraged to actively participate in the learning process. This approach contributes to improvement of cognitive and critical thinking. This focuses on testing and evaluating possible solutions in specific situation, followed by choosing the optimal solution based on the arguments. These represent important attributes to future specialist in science domain.

Keywords: discovery learning, creativity, motivation, participative methods, heuristic conversation.

INTRODUCTION

Learning is a very complex and important social phenomenon for humans and society. It is studied by many sciences as psychology, pedagogy, ethics, and sociology, etc. Learning is situated and is the result of the contribution of several disciplines such as physiology, psychology, and pedagogy.

Psychology describes the learning process, discovering its regularities. Pedagogy studies learning as operational activity because it comprises different techniques for human transformation. Learning view as a product is especially the result of human and scholastic activity.

Some scientists consider education as everything that overlaps human behaviour. They consider that any man is capable to assimilate specific techniques from the simplest one to the more complex. Through learning all thinking forms are developed: human activity and behaviours, motivation, ideals, and aspirations.

The man is a very complex organism. It has an open nature, being capable of interact with the environment, modelling it for own purposes. It can self-regulate. It is the learning result and a learning necessity. Without education a person cannot achieve the goal necessary for each level, he cannot evolve for higher stages.

Education is possible due to specific human characteristics, nervous system and analyzers structure. Learning supposes development and this is realised through intuition. Our cerebral cortex has a synthetic analytical function. The information is shared through flexible informational structures which finally form the systems. Education change and reorganise those structures. The operative character of the nervous activity is realized, and as consequence, is evidenced by a specific human characteristic that of putting everything in modern and structured relation.

All these external influences perceived and realised by the organism are mediated trough the internal activity. The humans acquire themselves interests, motivations, and sensitiveness during life. Not all experiences influence a person.

As learning in general can be considered any acquisition which allows a person to obtain a permanent equilibrium in itself and in its human activity. It means assimilation, knowledge, skills and ability achievements by

acquiring different working techniques. This form of activity is specific to humans. Assimilation through interaction is specific to our activity. It supposes the entry into action of all human processes of the whole human being.

It is important for the educable to properly use the assimilated knowledge. They must understand that learning is learned. At the base of human learning lies the motivation embodied in needs.

Good results for increasing the level of cooperation have been obtained through the collaborative project techniques[1].

Another approach that may be suggested is that of organise meeting between educable and remarkable personalities from different scientific domains[2].

A good teacher should be able to maintain equilibrium between the society needs and expectations, the educible psycho-emotional profile and the educational system requirements[3].

METHODS

The most frequent type of learning is by *conditioning that is carried out according to the pattern of conditioned reflexes*. It is developed through the formation of reactions and associations with different stimuli acquired during the life course. The most important of these reactions is the ***anticipatory reaction***.

Motor learning (sensory-motor) supposes acquiring a system of criteria and standards of material objects. This type comprises learning the verbal systems of conventional signs. The activities involve the sensory and motor effectors organs.

Verbal learning allows knowledge systems assimilation: language, words, aso.

Intelligent learning (discovery learning) involves concepts, notions and abstract categories learning. It engages in a special way the qualities of thinking. Its modalities imply *originality*, *independence*, *divergence*. This learning type depends on the person's cognitive and affective desire of involment[4].

The **algorithms** are used in different situations, improving the divergent thinking. It supposes to find more solutions to solve a problem. Also, the divergent thinking is positively influenced by a creative learning atmosphere and good scientific results[5].

Different **exposure** types are presented in table 1.

Table 1. Classic and modern exposure types

Classic	Modern
story	lecture debate
description	lecture application
explanation	conference debate
enunciating	exhibition with opponent
logical demonstration	informing
school lecture	microsymposium
master course	
training	

Heuristic conversation plays a very important role in teacher-student dialogue. The key to success is determined by the question, respectively its structure. Are recommended questions as: *Why*? *For what*? *How*?

Other suggested methods are the *discussions and debates*, *problematization* or *training by problem solving*, *written communication*.

The technique the *ideas tree* is used as a way of synthesizing knowledge about a given topic, in the form of ideas. It can be used both in the evocation and sense realization phase.

Objective:

- training the synthesis capacities of all the knowledge related to a given topic;
- forming the ability to group ideas into sub-themes.

Stages:

- the proposed theme for the respective activity is announced;
- the class is divided into groups. The number of groups will coincide with the number of subtopics;
- a representative of each group will extract from a bowl a ticket with a subtopic about which his/hers group will have to write. After the representatives return to the group, all members will consult and write on a sheet of paper, cut in leaf form, all the ideas that come to mind regarding the subtopic received;

- after all the groups have exhausted their ideas, one representative will read what was written. The teacher will present the logical order of the subtopics, thus achieving coherence.

DISCUSSIONS

The teaching-learning process can be classified using different criteria. It can involve the *direct personal experience*, a *verbal association* or *multiple discrimination*. From the point of view of the ***psychic activity*** the studying process can be: *latent* (unconscious immediately, spontaneous), *spontaneous*, *hypnotic learning*, *conscious* (through understanding and anticipation), *intelligent* (by making the bypass road), by *discovery*/*creative*/*inventive* (through trials and errors).

According to the administering human experience the acquisition information can be: *algorithmic*, *heuristic*, by *modelling* and *analogy*, through *creations*.

A new method frequently used is the *discovery learning* which is characterised by creativity.

Over time have been develop many theories regarding the educational system. Initially the principal roll was put on memory (retention) by rehearsal and their timing over time. Another aspect regarded the influence of the exercise and its value. Also the theory of trial and error needs to be mentioned. It considered that the education could be adjusted through replays. Another theory considers opportune the transferring into learning. The information thus perceived could have a positive or negative impact on the educable. It is considered that a well-formed skill facilitates the formation of other one. But in reality there are situations in which some already formed habits negatively influence the learning process.

The modern theories have the purpose to synthesize and order what has been achieved in the educational process and bring *new elements*. The central problem was and still is the clarification of the essence and the mechanism of notions formation and learning.

According to some educational currents notions can be learned *through perception*, creating an image about the object. Another sustain that concepts could be assimilated through *objects actions*, ***perception*** being ***included in the action***. The action with objects becomes internalized and on the plane of thought becomes a logical, abstract operation. The thinking essential feature is to be operative.

It is known that interests evolve with age, the cognitive concern not being completely outlined. The learning process through objects is a permanent source of educable interest formation. The lectures can be scientifically prepared. Educable motivation through active action[6], persistent and selective orientation towards a preferred direction, guides and directs human behaviour. It is a force which propels the learner energy and effort. Significance has the capacity to transform the *constraint* motivation into *ambition*, *success* motivation, or *desire to know as much as possible*. The reasons to overcome the limits can be inherent or extrinsical, social, cognitive (scientific curiosities) or of self-realization.

The learners present different affective states, temperament, aptitudes, social stage. Our emotions are like a clock, or a control device. It is said that a person's power is more than he feels. Irritability, instability, insecurity and inferiority complexes are often the results of emotional shocks suffered in the family or school with consequences in learning performance. The teacher attitude playes an important role in students tensile states, being able to positively influence it. The temperament often put its mark on learning activity.

Reconsideration of the *student-teacher* relationship ensures the didactic success. It is also recommended the revaluation of the pedagogy concepts about didactics and learning process, and change the report between teaching and learning in the net value of the last one. The concept of modern teaching outlines the atmosphere in which the learner is in the center of the learning process[7]. Knowledge acquisition is an active process in which the student's freedom of action is dominant. The teacher guides the training so as to contribute to the learning interest activation. He has to advise them how to learn to learn.

The **interactive methods** base is *action*, by stimulating imagination, intelligence, creativity and thinking. The students are actively involved in the process, increasing their responsibilization, and analytical capacity, facilitating the information acquisition. Considering their principal function these techniques have four directions: actual *teaching-learning methods* (cascade, share pair cycles, reciprocal teaching), *fixing, systematizing and knowledge verification* (causes and effect diagram, lotus technique), *solving problems by stimulating creativity* (brainstorming, study case) and *group research* (team experiment, research group experiment)[8, 9].

Utilisation of such methods by students from technical domain for three years, improved their abilities, knowledge, independency and interest for work, but also the desire to take part at conferences and develop patens ideas[10].

Attractiveness of theoretical courses can be increased by interactive means. Short filmed demonstrations or multimedia transmissions could be successfully integrated into lectures[11].

Improvement of the teaching methodology-the training methods system

In developing the methods capable of modifying the students behaviour is start from:

- *the human socio-historical experience* (cultural heritage). The methods used to give such information could be based on ***oral communication*** (*oral language* or *expositive* (affirmations)), ***written communication***, ***visual-oral*** or ***interior***;
- personal experience. Could be used the organised reality exploration (objective, intuitive). The directions may be through *direct exploration of real objects and phenomena* or *indirect exploration through reality the substitutes*;
- experience gained through practical action, intervention, reality transformation. The methods are fundament on practical action (operational). These could be made through *effective action* (real) or *simulative* (fictive).

The combination of training methods during the course hours must be an optimal one of all the components. The directions chosen must have high performance and maximum efficiency. There must be a dialectical unity between the learning content and the instruction methods. The methods used depend on:

- the teacher competence and personality;
- age psychology and educable individuality;
- group psycho sociology.

The use of different methods is usually associated with certain means of learning (material tools). The choice of methods is a deliberative act.

The new trends include concerns regarding the integration of education with practice and scientific research, creating priority directions for methods reinvigoration. Should be emphases the formative-educational character of the methods that have efficiency in cultivating the entire individual potential. It is recommended the utilisation of *active* and *participative* methods in all learning activity. The active methods are based on the educable intrinsic motivation. The emphasis is placed on the use of information in order to obtain new ones to solve the problem situations. It supposes that subjects have an independent action of search, research, reconstruction and truths reinvention. The system need to have an *applicative character* (practical methods) which promotes work spirit. It is recommended to combine the methods of individual work with those of team and collective work.

The *interactive didactic internships* offer beneficial opportunities for pedagogical organization of a thorough, easy and pleasant learning. At the same time it has a pronounced active-participatory character on the part of the students, with possibilities of cooperation and efficient communication. The systematic use of active and interactive methods leads to a mutual action of cognitive, social and affective influence within the groups, thus noting their formative values:

- contribution to critical thinking development;
- creativity stimulation;

- active involvement of educable in learning act;
- focusing on independent and collaborative learning;
- argued opinions forming;
- respect colleagues opinions.

Computer assisted learning is more and more present in the educational activities. It represents a viable alternative to develop collaborative projects, bringing together students from different institutions. Due to the limited face-to-face interaction some challenges are born. In planning such a teaching system is recommended to ensure the appropriate mechanisms to support the group internal emotional assistance, student-student and teacher-student reciprocation feedback. The learning process dynamization is directly influenced by the participants degree of involvement and interaction. The collaborative projects developed through virtual environment may have a determinant impact for students teamwork progress[12]. Implementation of such techniques requires also the models and protocols predefined of in order to ensure the educable maximisation acquisition[13].

An important part of the science domain is focus on research and developments. Currently many collaborative projects are developing. Was demonstrated that their success directly depend on the level of scientific knowledge of those involved, but especially of the strategic management adopted, and of the experience in field of the decider persons[14]. The students implication in collaborative projects during studies can ensure a valuable background for future.

Studies made regarding educational collaborative techniques present two types of groups: one characterised by a dominant member and another in which all members have an approximately equal contribution. For optimum results is recommended a combination of the two situations. It is considered that utilisation of a flexible collaborative approach increase the members self confidence and personal acquisition level based on informal and group experience[15].

For an interactive learning, one available action mean for the teacher are the *teaching methods*. The focus is on using actively participatory methods. Characteristic for these is participation, active involvement, and full commitment with all possible resources of the subject in the act of learning[16].

There is a tendency to instrumentalization and technicization of contemporary teaching methods. The new didactic methodologies promote the principle of lifelong education which tends to ensure the acquisition of appropriate techniques of intellectual, independent (self-teaching) work, including effective methods of information and documentation that will serve as a tool of self-instruction and self-education throughout the life.

university lecture + debate→debate lecture or *conference debate*

CONCLUSIONS

- with Bologna system implementation, the vision on educational system had to be redesign in order to allow optimum learning achievements;
- the new methods and techniques proposed need to be chosen so as to avoid the prohibitions, and/or sanctions, such actions being able to lead to block the educable personality, reaching a possible imbalance state;
- learners intellectual and spiritual aspects must be perceived by the educator in order to adopt the optimum teaching system, if is necessary by integrating different procedures;
- independent of the approach, the tendency of self-realization and affirmation must be nurtured and directed to the educator avoiding the tutelage;
- the proposed alternatives for science domain are in accordance with the new educational directions. They are based on interdisciplinar system, on development of practical skills through discovery and interaction, on educable native talents improvement.

The book provides access to humanity cultural values.

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TRENDS IN VALORISATION OF SPENT COFFEE GROUNDS: A REVIEW

Simona PERTA-CRISAN, Claudiu URSACHI, Florentina-Daniela MUNTEANU*

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Faculty of Food Engineering, Tourism and Environmental Protection, "Aurel Vlaicu" University, 2 Elena Dragoi, Arad 310330, Romania
Corresponding author email: florentina.munteanu@uav.ro

Abstract: *Coffee is nowadays one of the most appreciated and also consumed beverage. Its consumption presents many benefits for humans, but has also a great inconvenience because of the major quantities of waste resulted in the brewing process, which is not further exploited and reaches the environment with a significant negative impact. This residue is represented by spent coffee grounds (SCG). Due to its chemical composition, SCG represents a good source of some useful active compounds, which can be exploited for obtaining high-value products. This paper overviews aspects regarding the coffee world production, consumption and total quantities of residues resulted from coffee industry, pointing out the possibilities of SCG valorisation. Thus, it reviews the most important researches regarding SCG potential use in different domains, such as energy, agriculture, food and health, material construction and wastewaters treatment.*

Keywords: coffee, spent coffee grounds, biofuel, value-added product.

INTRODUCTION

Nowadays, coffee plants are cultivated in more than 70 countries. Coffee berries are obtained from two usually grown species: *Coffea canephora* (Robusta), the most widely cultivated variety, especially in Central Africa, Southeast Asia and Brazil and *Coffea arabica* (Arabica), cultivated in Latin America, Eastern Africa and Asia. About 60% of coffee beans worldwide production is arabica and the rest of 40% is Robusta (Batista et al., 2016).

Coffee berries are picked when ripped, then are processed and dried, becoming coffee beans. Roasting of coffee beans constitutes a very important stage in coffee obtaining process, because it influences physically and chemically properties of beans and determine their sensorial quality, especially flavour and colour. Roasted beans are grinded and brewed with near-boiling water, in order to obtain the coffee beverage.

Coffee is one of the most commercialized commodities worldwide, after petroleum. In the same time, it is the second most popular beverage, next after water (Mussatto et al., 2011b; Girotto et al., 2018). Thus, there is a great worldwide interest for its production and commercialization.

COFFEE WORLD PRODUCTION AND CONSUMPTION

According to latest statistical data provided by International Coffee Organization (ICO), total coffee production in 2018 was about 10.2 million tonnes, 6 million tonnes being represented by Arabicas and 4.2 million tonnes by Robustas. Leading coffee production country was Brazil, with an amount of about 3.7 million tonnes, meaning 36% of total. Compared to world production registered in 2015, in 2018 can be observed a major increase of about 10% (http://www.ico.org/prices/po-production.pdf).

Regarding coffee world consumption for a 2018/19 period, a total of about 10 million tonnes were consumed. Leading continent was Europe, with a total amount of about 3.3 million tonnes, followed by Asia & Oceania with 2.1 and North America with 1.9 million tonnes. European Union was the consumption's leader in Europe, with a total amount of 2.7 million tonnes, which represents 27% of total, followed by USA with 1.6 million tonnes. In 2018/19 it was registered an important increase of 6% in world coffee consumption, relative to 2016/17 period (http://www.ico.org/prices/new-consumption-table.pdf).

In 2017, the largest coffee-consuming country worldwide was Finland, with 10.35 kg

per capita, followed by Netherlands with 9.58 kg per capita. USA was only 18th place, with an amount of 4.43 kg coffee consumed per capita (https://www.statista.com/chart/8602/top-coffee-drinking-nations/).

COFFEE RESIDUES

As world total coffee consumption increases every year, an important problem becomes to be the major quantities of organic waste resulted from coffee industry: by-products from beans processing and roasting (>50% of the fruit mass) and spent coffee grounds (SCG), from beverage preparation (Campos-Vega et al., 2015a). SCG is the solid residue which remains after roasted coffee beans are grinded and brewed, both in coffee shops chains and in industry, for obtaining instant coffee and represents the most abundant coffee by-product (45%) (Murthy and Naidu, 2012).

SCG chemical composition

Spent coffee grounds contain important quantities of organic compounds (phenolics, lipids, proteins, lignin, cellulose, hemicellulose and other polysaccharides), which determine its importance as a real source of valuable products (Kourmentza et al., 2018). Thus, Table 1 presents values reported by literature for most important components of spent coffee grounds (Massaya et al., 2019).

Table 1. Values reported by literature for components of spent coffee grounds (wt%) (Massaya et al., 2019)

Component	SCG
Hemicellulose	32-42
Cellulose	7-13
Lignin	0-26
Lipids	2-24
Proteins	10-18
Ash	1-2
Caffeine	0-0.4
Chlorogenic Acids	1-3
Moisture	50-60
Pectins	0
Total sugars	7-14
Total dietary fibre	21-59

Polysaccharides fraction covers about 50% of SCG total mass, of which about 50% are galactomannans, 25% arabinogalactans and 25% cellulose (Oosterveld et al., 2003). Presence of mannose, galactose, glucose and arabinose, polymerized into hemicellulose and cellulose (Ballesteros et al., 2014; Mussatto et al., 2011a) and high content of galactomannans (Simões et al., 2013) are highlighted in SCG, lignin being also present in a significant amount (Pujol et al., 2013). Dietary fiber represent about 43% of total SCG dry weight (42% insoluble, 1% soluble fibre respectively), which are approved to be used as raw material to develop functional foods. The fibre from SCG includes, among others, resistant starch, oligosaccharides and manno-oligosaccharides (Campos-Vega et al., 2015b; Vázquez-Sánchez et al., 2018; Tian et al., 2017).

There are also present some bioactive secondary metabolites, such as diterpenes, sterols, chlorogenic acids, flavonoids and caffeine (Massaya et al., 2019). Caffeine is a major biological active compound of spent coffee grounds (Cruz et al., 2012b).

SCG amounts

Brewing of 1 kg of soluble coffee generates 2 kg of wet SCG (Mussatto et al., 2011b). At the same time, 1 kg of green coffee beans produces 0.65 kg of dried SCG (Kookos, 2018). Thus, usually accepted mass ratio of generated SCG to produced coffee beans is 0.65 and the mass ratio of SCG to roasted beans is 0.91 (Eshetu, M. 2018). As a consequence, a high amount of more than 6 million tonnes of dried SCG is generated worldwide each year (Hardgrove and Livesley, 2016).

SCG impact on the environment

Kamil et al. (2019) achieved an estimation of total amount of wet SCG produced per year and its impact on the environment, by the CO_2 emissions from landfills point of view. Thus, considering the total number of coffee cups daily drunk of 1.4 billion and every cup waste of 30 g (15 g ground coffee beans and 15 g water), total amount of SCG landfilled can be estimated at 15.33 million tonnes per year. Considering that one tone of SCG produces 682 kg CO_2, annually there are generated 28.644 million tonnes of CO_2 from landfilling, a quantity equivalent with that produced by 10.6 million liters of burned diesel fuel.

Even if SCG contain polyphenols and tannins, which are compounds with established ecotoxicity, this residue is either disposed of in sanitary landfills or incinerated (Mata et al.,

2018). This practice is dangerous both for humans and ecosystems, especially the soil one (Mussatto et al., 2011b; Cruz et al., 2012b). Thus, an interesting method for decreasing SCG toxicity by elimination the phenolic compounds from its structure was proposed, meaning a biological treatment with fungal strains from genus *Penicillium*, *Neurospora* and *Mucor* applied before releasing this residue to the environment (Machado, 2009).

Because of its content in caffeine, fatty acids and metals, SCG can be toxic for aquatic organisms on a long-term exposure (Fernandes et al., 2017). Its high humidity, which may exceed 65% by mass, acidic pH and listed toxic constituents, are responsible for high environment damage (Leifa et al., 2000; Páscoa et al., 2013). Due its organic nature, SCG may form leachate, a major pollutant of waters, when the final destination are waste landfills (Renou et al., 2008; Foo and Hameed, 2009).

Interest in SCG exploitation

Valorisation of spent coffee grounds presents nowadays a major interest, both for researches and industry sector. Some reasons conduct to these tendencies: the large number of organic compounds contained, such as phenolics, lipids, carbohydrates, proteins, which constitutes potential functional food ingredients (Campos-Vega et al., 2015a); some bioactive secondary metabolites, such as diterpenes, sterols, caffeine, because of their physiological effects (Bonita et al., 2007); SCG physical structure enables fast removal of these substances, by using the suitable solvent; SCG is a residue available in large amounts, because of the immense worldwide coffee consuming (Peshev et al., 2018).

To reduce the negative impact of SCG disposed of in landfills, there is a real interest for its utilization as a significant substrate for obtaining some useful value-added energy and non-energy by-products, as functional additives or antioxidants (Zuorro and Lavecchia, 2012; Esquivel and Jiménez, 2012; Li et al. 2014; Campos-Vega et al. 2015a; Kourmentza et al., 2018; Kovalcik et al., 2018; Karmee, 2018; Janissen and Huynh, 2018; Atabani et al., 2019; Iriondo-DeHond et al., 2019). Many important food companies take seriously into account utilization of coffee residue as a source for obtaining chemicals or energy (Kookos, 2018).

POSSIBILITIES OF SPENT COFFEE GROUNDS VALORIZATION

Till present, several important applications have been experimental developed for spent coffee grounds valorisation, especially as biofuels, composts and animal feed, a functional ingredient for food products with real health benefits, bio-composite materials, decontaminants of wastewaters.

Energy

A very remarkable utilization of SCG is energy production. Due to its high organic content, SCG is very attractive for being use as biomass. It represents an alternative source of energy and biofuels production (Li et al., 2014), namely fuel pellets, biochar, bio-oil, biogas, biodiesel and bioethanol, besides the other value-added products (Kondamudi et al., 2008; Atabani et al., 2019).

Direct combustion

SCG can be directly burned, in order to produce heat energy. Calorific value measurements demonstrated that coffee residues possess high energy content, proving a higher heating value than woody biomass (Bok et al., 2012). SCG was tested as combustible in some various ways, by direct boiler burning both alone, as pellets or woodchip logs and also mixed with other biomasses, such as sawdust pellets or pine sawdust pellets (Limousy et al., 2013; Jeguirim et al., 2014; Limousy et al., 2015; Jeguirim et al., 2016; Kang et al., 2017). Results of these combustion studies were summarized by McNutt and He (2019). Thus, boiler-style combustion of SCG produced higher heating value than wood pellets, at the same water content, but it is a need to reduce emissions of O_2, CO and NO_x in flue gas. When burning SCG pellets, heating value level was closed to standard agro-industrial pellets, but slightly lower. By combining 20% SCG and 80% pine sawdust and burning as woodchip logs, combustion yields were comparable to regular wood logs, while pelletization of SCG and pine sawdust conducted to higher particle emissions

in flue gas than pellets obtained with pure sawdust.

Biochar, bio-oil and biogas

SCG pyrolisis leads to obtaining of biochar, bio-oil and biogas (Ktori et al., 2018), depending on technique and reaction parameters (slow or fast pyrolisis). Biochar is suitable for being used as a solid fuel in industry because of its high calorific value (Tsai et al., 2012), as a fertilizer in arid fields (Ktori et al., 2018) or for activated carbon (Safarik et al., 2012). Bio-oil was studied as a precursor for biodiesel production (Li et al., 2014) or as a chemical, due to its insecticidal and bactericidal properties (Bedmutha et al., 2011). Biogas can be used as a power source in engines, turbines and boilers (Ktori et al., 2018).

Vardon et al. (2013) proposed a complete utilization of SCG. Thus, coffee lipids extracted from SCG were subjected to transesterification, for producing biodiesel, while biochar and bio-oil were obtained from defatted SCG, through slow pyrolisis (Figure 1). Generated biochar showed a calorific value of about 31 MJ/kg.

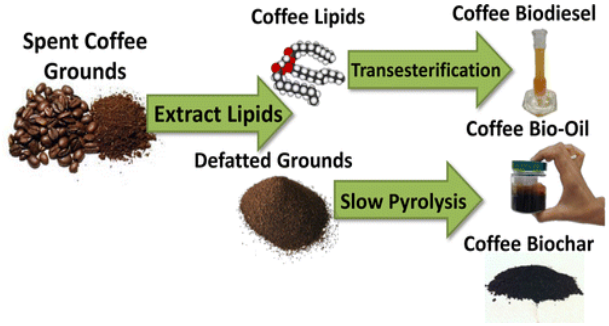

Figure 1. Complete utilization of spent coffee grounds to produce biodiesel, bio-oil and biochar (image from Vardon et al., 2013)

Regarding pyrolisis process applied for bio-oil production, Bok et al. (2012) obtained a maximum yield of bio-oil (55%) at 550°C, Li et al. (2014) recorded highest yield (66%) at 630°C, while Ktori et al. (2018) achieved maximum amount (36%) at 540°C. Because of SCG high moisture content, of approximately 50-60%, a pre-drying phase need to be applied prior to pyrolisis (Girotto et al., 2018).

Biodiesel

SCG chemical composition is characterized by large amounts of oil, with values around 10-15% (Al-Hamamre et al., 2012). Thus, it can be exploit with notable results in producing biodiesel. Nowadays, there are many researches which demonstrate its potential in this sense (Kondamudi et al., 2008; Vardon et al., 2013; Girotto et al., 2018; Kookos et al., 2018; Mata et al., 2018; Atabani et al., 2019; Kamil et al., 2019; Masaya et al., 2019; Tongcumpou et al., 2019). One possibility for biodiesel production process is the method which implies the extraction of lipids from spent coffee grounds first, by using solvents, then the transesterification reaction in two steps: acid esterification, followed by alkaline transesterification (Caetano et al., 2014). There is one more possibility for obtaining biodiesel, when transesterification is performed directly or *in situ* on SCG biomass, without prior lipids extraction, in only one step, by acid transesterification (Park et al., 2016; Liu et al., 2017). Conversion in two steps is suitable when coffee oil is highly acid (Al-Hamamre et al., 2012; Caetano et al., 2014).

However, some studies demonstrated that it is difficult to support an economically feasible process for biodiesel production from SCG (Kokoos, 2018). Kamil et al. (2019) concluded that profitability appears only when the production capacity of a biodiesel factory is in order of 10.000 tonnes SCG/year, smaller capacities demanding high initial investment per unit produced.

Bioethanol

Because of its high content in cellulose and hemicellulose, SCG represents a potential source for biotechnological production of bioethanol, further used as a fuel. This procedure needs an initial conversion of hemicelluloses and partially cellulose into fermentable sugars, by hydrolysis (Obruca et al., 2015). For converting SCG sugars to ethanol, a fermentation needs to be applied, by using *Saccharomyces cerevisiae* yeast (Mussatto et al., 2012). Bioethanol production proved efficiency, but due to fatty acids and triglycerides content from SCG, the hydrolysis process of polysaccharides was restricted. Thus, it is more advantageous obtaining

biodiesel than conversion to bioethanol (Kwon et al., 2013).

Agriculture

Due to its content in polysaccharides and minerals, SCG has been studied as potential organic fertiliser. In order to stimulate plants growing, by improving their mineral nutrition, some researches regarding utilization of SCG as organic amendments have been realised, its application being either as such or as compost (both fresh and initially composted or composted directly on the soil) (Murthy and Naidu, 2012; Cruz et al., 2014b; Cruz et al., 2015; Campos-Vega et al., 2015a; Cervera-Mata et al., 2019). Different studies noticed that low amounts of SCG increased soil mineral content, bioactive compounds and antioxidant activity (Cruz et al., 2012a; Cruz et al., 2014a). However, because of its high C/N ratio, acidity and total content of phenols and caffeine, its direct application on soils might be harmful, both for plants and soil microorganisms (Hardgrove and Livesley, 2016). Thus, Gomes et al. (2013) reported that composting of SCG, before its application, may reduce toxicity to plants, due to decreasing of total phytotoxic constituents' amount. Added at the beginning of composting, SCG supplies compounds such as mannose, galactose, arabinose, glucose, proteins, calcium and phosphorus, enhancing degradation of waste, by aiding microbial activity and enzymes generation (Murthy and Naidu, 2012; Wu, 2014). SCG can also be considered a natural herbicide, being able to eliminate weed seeds in composting (Low et al., 2015). Zhang and Sun (2017) proposed the combination, in different proportions, of cow dung and SCG, as amendments in two-stage co-composting of green waste. The most qualitative, mature and rapid compost was obtained when 20% cow dung and 45% SCG were combined, in only 21 days. As well, nonphytotoxic compost products were caused, improving compost properties and nutrient content.

Because of SCG physical properties, such as small size particles and high surface area, this residue might help water management in acidic soils, which possess low cohesion and are sensitive to erosion (Kasongo et al., 2013). Turek et al. (2019) examined physical-hydraulic soil properties modifications, in case of SCG administration. It was observed an improvement of soil water retention and aeration, its application proving efficiency in soils with poor retention capacity. However, larger than 10% SCG contents are not recommended to be applied in sandy loam soils.

Considering its high nutritional content, SCG was investigated also as a supplement in animal feed, for pigs, chickens, rabbits and ruminants (Claude, 1979; Givens and Barber, 1986). However, because of its high content in lignin (~25%), tannins and caffeine, SCG proved a limited utilization in this regard (Cruz, 1983). Fuller (2004) concluded that a higher concentration than 2.5% of the last two compounds make SCG inedible, because they produce a diminution of protein digestibility. Seo et al. (2015) evaluated the effect of SCG inclusion, in concentration of up to 100 g/kg in the concentrate of ruminants, as a functional feed ingredient, on the yield and quality of milk. Results showed that milk production and composition were improved, with no side effects regarding feeding behaviour or apparent digestibility at ewes.

Food and health

In addition to SCG application in animal feed, currently there are studies which support the usage of this by-product as a nutraceutical or food functional additive, improving both nutrition and health (del Castillo et al., 2014).

SCG constitutes a valuable source of phenolic compounds and melanoidins, which can be further included as functional ingredients in human diet (Borelli et al., 2004; Mussatto et al., 2011c; Zuorro and Lavecchia, 2012; Xu et al., 2015). Thus, it was demonstrated the SCG antioxidant, antihypertensive and antimicrobial activities in intestine microbiota (Rufián-Henares and Morales, 2007; Campos-Vega et al., 2015b), with an important role in preventing diseases related to free radicals (Wang et al., 2011). Phytochemicals from SCG can be digested, absorbed and fermented in colon, exerting healthy effects by influencing the metabolic

activity of the microbiota (López-Barrera et al., 2016).

SCG phenolic extracts can also be used as anti-inflammatory additives (Lopez-Barrera et al., 2016) and dermatological anti-melanogenesis agents (Huang et al., 2016). Regarding extracting of natural antioxidants and caffeine from SCG, there were proposed different methods, such as solid-liquid extraction using aqueous alcohol solution (methanol, ethanol and isopropanol) (Mata et al., 2018) or by pressurized liquid extraction (PLE) method with water and ethanol (Shang et al., 2017).

Dietary fibre can be fermented by colonic microbiota, releasing short chain fatty acids, with anti-inflammatory properties. Thereby, it can protect the onset or progression of inflammatory diseases, such as inflammatory bowel, colon cancer and rheumatoid arthritis (López-Barrera et al., 2016; García-Gutiérrez et al., 2017; Hernández-Arriaga et al., 2017). Due to its rich content in dietary fibre, SCG might be a good source of these compounds in the food industry (Martinez-Saez et al., 2017a). Vázquez-Sánchez et al. (2018) evaluated antioxidant dietary fibre extracted from SCG as a functional food ingredient, by their adding in biscuits. Antioxidant capacity after in vitro digestion, bioaccessability of phenolics and aminoacids and also total dietary fibre content were improved. Same study seemed to indicate that anti-diabetic compounds, with inhibitory effects on α-glucosidase activity, might be released in small intestine during these enriched biscuits digestion, making them capable to regulate sugar metabolism. Thus, dietary fibre extract from SCG might help production of foods diabetics friendly (Martinez-Saez et al., 2017b).

Other potential use of SCG is obtaining of valuable bio-sugars, such as oligosaccharides, manno-oligosaccharides and mannose, after its delignification and defatting, process which proved large-scale feasibility (Nguyen et al., 2019).

Peshev et al. (2018) revealed utilization of SCG for obtaining water extracts with sufficiently high caffeine concentration. Appliance of nanofiltration to these extracts, by using a suitable membrane, conducted to valuable products, as permeate and retentate fractions. Permeate can be further used for soft and energy drinks, while retentate for coffee drink or as functional food ingredient.

Materials construction

Because SCG contain high amounts of cellulose and hemicellulose, it has the potential to be part of bio-composite materials, being applied as filler and additive for polymer composites (Baek et al., 2013; García-García et al., 2015; Wu et al., 2016; Moustafa et al., 2017a; Moustafa et al., 2017b).

Vilela et al. (2016) successfully obtained a material which is rich in insoluble fibres by using the polysaccharide-rich fraction from SCG, obtained by alkaline hydrogen peroxide treatment of the coffee residue. Ballesteros et al. (2018) enhanced light barrier of carboxymethyl cellulose films for food packaging, by incorporating polysaccharide-rich extracts from SCG. These films proved almost similar properties as those noticed in literature, but their usage must be limited at applications where aesthetics is not important.

SCG was also studied as a subgrade material for construction industry, mixed with another adequate waste materials with proved compression resistance (e.g. recycled glass) (Arulrajah et al., 2017).

Wastewaters treatment

Considering its high lignocellulosic content, SCG proved to be an efficient adsorbent (Ballesteros et al., 2014), more exactly a precursor of activated carbon used for removing of basic dyes from dye-contaminated industrial waters (Pagalan et al., 2019). Due its unique microporous structure with a high surface area of about 300–1000 m^2/g and metal-chelating activity, it proved efficiency in adsorption of phenols and also heavy metals (Castro et al., 2011; Zuorro and Lavecchia, 2012; Davila-Guzman et al., 2013; Liu et al., 2015).

Besides its proven efficiency in wastewaters treatment (Franca and Oliveira, 2009), activated carbon from SCG can also be used as a removal of the organic matter from landfills leachate (Chávez et al., 2019).

Complete utilization of wet SCG

Tongcumpou et al. (2019) proposed a complete method for wet SCG utilization, by its continuous subjection to three processes: the extraction of antioxidants, direct biodiesel production from the remanent SCG and bio-char obtaining from defatted SCG. By antioxidants extraction with methanol, free fatty acids and water were also extracted, making possible direct *in situ* transesterification for obtaining biodiesel, with no previous drying and conditioning of SCG waste. In third process, defatted SCG was transformed in bio-char briquette, by a slow pyrolisis. Applying this chain of processes for SCG valorisation, energy and time consumption was reduced. In the same time, the energy content in bio-char briquette proved to be sufficient to support all processes.

CONCLUSIONS

Although many current studies indicate, as a result of extensive researches, some achievable and environmentally sustainable methods regarding valorisation of spent coffee grounds, this residue is nowadays still disposed of in landfills or directly burned. The main reason is that the majority studies have been realised at a laboratory scale, with no proved economic profitability and reliability at industry level. Thus, it is imperative that future researches to be accomplished together with industry sector, in order to demonstrate their viability for large scale implementation and economic feasibility.

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POSSIBLE APPLICATIONS OF THE BIOCHAR OBTAINED FROM SEWAGE SLUDGE

Dan DANCIU[1], Florentina-Daniela MUNTEANU[2*]

[1]Faculty of Engineering, "Vasile Alecsandri" University of Bacău, Calea Mărăşeşti, nr. 157, 600115, Bacău, România
[2]Faculty of Food Engineering, Tourism and Environmental Protection, "Aurel Vlaicu" University, Romania, 2 Elena Dragoi, Arad 310330, Romania
Corresponding author email: florentina.munteanu@uav.ro

Abstract: *The present review has in attention the valorisation of the sewage sledge from the wastewater treatment plants, as this represents a major concern for the public health and the environment. Its processing for the obtaining of the sludge-based biochar can be further used for the removal of some pollutants from the environment. The possibility to use the sludge-based biochar for the removal of heavy metals and of organic pollutants is presented.*

Keywords: wastewater, sewage sludge, biochar, heavy metals.

INTRODUCTION

The wastewater treatment plants (WWTPs) are receiving the sewage from different sources and might comprise water that carries wastes discharged from the residential, industrial and commercial establishments. The by-product of the WWTPs is the sewage sludge a biosolid (Turek et al., 2019) that is covered by a number of European legal acts that are focusing on the environmental and water protection, waste management and soil fertilization (E.C. Directive).

As a result of the population growth, the amount of produced sewage sludge is in a continuous increase, and as a consequence the efficiency of the treatment processes in the WWTPs is in a permanent improvement (Spanos et al., 2016; Tytła, 2018).

The composition of the sludge may consist of high concentrations of hazardous components. The main sources of heavy metals in the wastewaters are industrial and domestic activities, including the pharmaceuticals and cleaning products that are intentionally or accidentally discharged (Duan et al., 2018; Rizzardini and Goi, 2014).

Depending on the chemical composition of the wastewater and processes that are used in the WWTPs, the quality of the sewage sludge might differ. In general, the sludge from the residential wastewater might be rich in heavy metals and metalloids (Houhou et al., 2009; Vardhan et al., 2019).

The accumulated heavy metals in the sewage sludge are representing a serious problem for the environment because of their accumulation in the soil, and as a consequence the surface and groundwater can be subsequently contaminated. Ultimately, the crops and the food chain might be containing amounts of heavy metals that might have a negative impact on the animal and human health (Feizi et al., 2019; Tytła et al., 2016).

A report elaborated for the European Commission shows that by 2020 the total amount of produced sewage sludge at the level of EU27 is going to be around 13047000 tonnes of dry solid. Out of this amount about 44% is going to be recycled to the land, 32% will be incinerated and about 7% for landfill (Milieu Ltd, 2008).

As the biggest amount of the sewage sludge is intended for the use of land fertilization, the composition plays an important role. The highest concentration is represented by the organic matter and biogenic compounds, which play a special role in the growth of the plants (Zhang et al., 2017). Unfortunately, beside the necessary compounds, the content in heavy metals (chromium, copper, lead, nickel, mercury, and zinc) (Tytła et al., 2016) might have a negative impact on the environment and on the animal and human health.

CONTENT OF HEAVY METALS IN THE SEWAGE SLUDGE

Considering the provenience of the wastewater and the various anthropogenic activities the load in heavy metals of the sewage sludge is high. According to the work of Gawlik (Gawlik, 2012), the results are presented in Table 1.

Table 1. The range of heavy metals contained by the sewage sludge from the European Union countries (Gawlik, 2012).

Trace metal	Range of determined values in EU countries	Unit
Al	0.1-60	%
Ag	0.1-14.7	mg/kg DM
As	5.6-56.1	mg/kg DM
Ba	41.5-579.9	mg/kg DM
Cd	0.3-5.1	mg/kg DM
Co	1.5-16.7	mg/kg DM
Cr	10.8-1542.2	mg/kg DM
Cu	27.3-578.1	mg/kg DM
Fe	0.2-14.9	%
Hg	0.1-1.1	mg/kg DM
Mn	75.2-959.7	mg/kg DM
Mo	1.7-12.5	mg/kg DM
Ni	8.6-310.0	mg/kg DM
Pb	4.0-429.8	mg/kg DM
Se	3.4-53.6	mg/kg DM
Ti	65.2-1070.9	mg/kg DM
V	2.3-135.4	mg/kg DM
Zn	0.0-0.1	%

*DM-dry matter

The presence of heavy metals in the sewage sludge might be an inconvenient, but for the obtaining of the sewage sludge biochar their negative impact on the environment can be reduced if the combustion is performed at low temperatures, cases when some of the metals are transformed in stable forms and their leaching from the biochar is prevented (Ahmad and Alam, 2016).

OBTAINING BIOCHAR FROM SEEWAGE SLUDGE

For the mitigation of the risks associated with the presence of the heavy metals in the sewage sludge used as fertilizer in the agriculture were proposed a number of methods (Frišták et al., 2018; Hei et al., 2016; Herzel et al., 2016; Kominko et al., 2019; Meng et al., 2018; Suciu et al., 2015; Thomsen et al., 2017; Vogel et al., 2020; Wang et al., 2019c).

Recently, a huge interest was paid to the obtaining of the biochar based on the sewage sludge (Barry et al., 2019; Yin et al., 2019). An important advantage of using the biochar obtained from this raw material is that the heavy metals that are present in the sewage sludge will be in a stable form in the biochar, fact that will make the use of the biochar less aggressive in environmental application (Zielińska and Oleszczuk, 2015). Biochar can be described as a porous carbonaceous solid material that is obtained from residual biomass through slow pyrolysis (temperature range 450-650°C) under limited oxygen conditions (Colantoni et al., 2016; Mian et al., 2019; Thomsen et al., 2017; Xue et al., 2019). The main advantage of the biochar is that is an efficient adsorbent which is low-cost and can be produced from a large variety of biomass materials, including the sewage sludge. The sludge-based biochar was proven to have chemical stability with low metal leaching, that has the advantage to be recyclable and cost-effective (Mian et al., 2019; Wang et al., 2019b). The steps for the production of biochar are schematically represented in Figure 1.

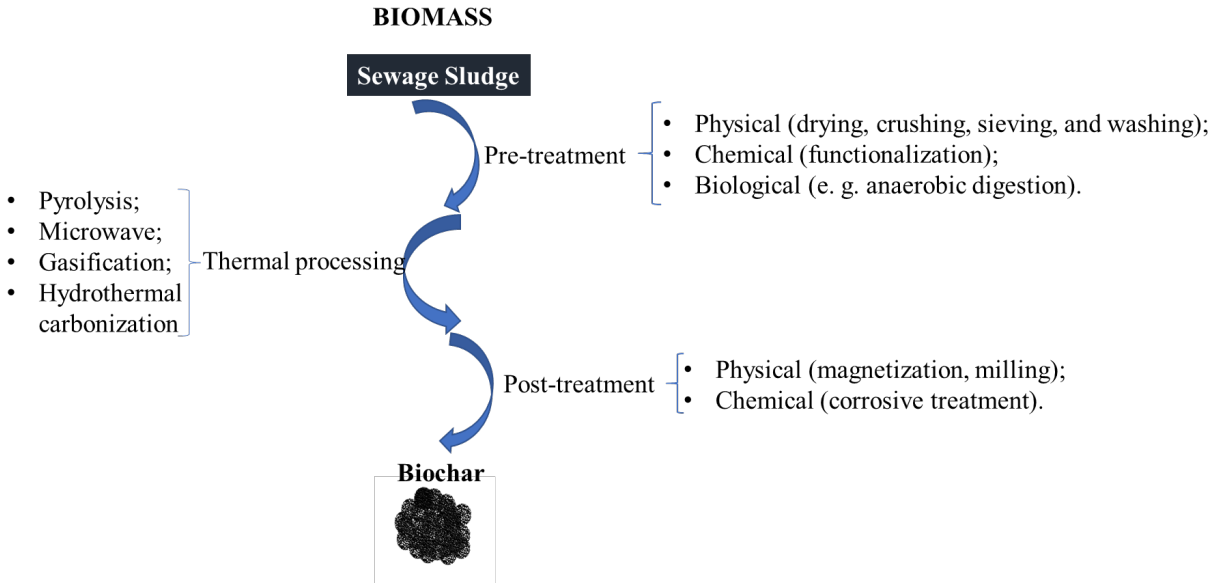

Figure 1. Steps for biochar production from sewage sludge.

Regarding the thermal processing of the pre-treated biomass, the most used methods are: pyrolysis, microwave digestion and hydrothermal carbonization.

Pyrolysis can be performed at temperatures between 100°C and 800°C in the presence of argon or nitrogen as control gases of the pyrolysis. Thereafter, the solid residues can be treated with acidic solutions for the increase of the specific surface area and porosity (Tu et al., 2014).

Use of the microwave digestion it usually implies three sequential steps: (i) impregnation of the sewage sludge with an acidic solution; (ii) chemical activation with a solution of KOH/KCl, and (iii) post-calcination (Gu et al., 2017).

Hydrothermal carbonization is performed at temperatures in the range of 150-250°C, and a pressure of 1.5-2.5 Ba for a retention time that might vary between 1 and 24 h (Zhang et al., 2018).

In comparison with the physicochemical properties of the sewage sludge, the properties of the sludge-based biochar need improvements that can be obtained by improving the carbonization conditions and/or by a post-treatment (chemical or physical)

In general, for improved characteristics of the surface and catalytically active sites of the engineered biochar, are used advanced synthesis methods (Mian and Liu, 2019).

APPLICATIONS OF SEWAGE SLUDGE BASED BIOCHAR

Most of the applications that are using the sludge-based biochar are focusing on the removal of some pollutants from the environment (Mian et al., 2019; Regkouzas and Diamadopoulos, 2019; Wang and Wang, 2019; Wang et al., 2019a; Xue et al., 2019; Zhang et al., 2019). Some environmental applications of the sludge-based biochar are presented in Table 2.

Table 2. Applications of the sludge-based biochar for the removal of some contaminants.

Contaminant	Adsorption capacity	Method for biochar preparation	Reference
Heavy metals			
Lead	51.20 mg/g	anaerobic digestion sludge under pyrolysis temperature of 600°C	(Ho et al., 2017)
	126.40 mg/g		(Ni et al., 2019)
	116.20 mg/g	pyrolysis of sewage sludge by electromagnetic induction, at 500°C	(Xue et al., 2019)
Cadmium	0.44 mmol/g	anaerobic digestion sludge under pyrolysis temperature of 600°C	(Ni et al., 2019)
	97.30 mg/g	pyrolysis of sewage sludge by electromagnetic induction, at 500°C	(Xue et al., 2019)
Organic pollutants			
2,4-Dichlorophenol	3.88 mg/g	Anaerobic pyrolysis of sewage sludge at 500°C	(Regkouzas and Diamadopoulos, 2019)
2,3,4-Trichlorophenol	1.32 mg/g		
Bisphenol A	24.89 mg/g		
Carbamazepine	761.10 mg/g		
Androsterone	0.006 mg/g		
Estrone	92.21 mg/g		
17a-Ethinylestradiol	0.011 mg/g		
Methylene blue	376.9 mg/L	Thermal decomposition at 800°C of sewage sludge (SS) and different ratios of nanoparticles (NPs: Fe and Ti) impregnated with chitosan	(Mian and Liu, 2019)

As shown in Table 2, the biochar obtained through different methods from the sewage sludge can be successfully used for the removal of some contaminants from the environment. Nevertheless, the efficiency of using the sludge-based biochar for the removal of some contaminants is promising and can be further considered for real environmental samples.

CONCLUSIONS

The biochar obtained from the sewage sludge is proving to be a good candidate for the removal of some pollutants from the environment. It was shown that the pyrolysis of the sewage sludge it will lead to biochars that can be used for the adsorption of some heavy metals or organic pollutants from different samples.

Future work should consider the optimization of the pyrolysis temperature, as this parameter plays an important role in the physical properties of the biochar as well as on the number of catalytic sites that allow a better adsorption capacity.

A special attention should be also paid to the use of other materials mixed with the sewage sludge for the obtaining of a biochar with improved properties as promising materials for environmental remediation.

Unfortunately, most of the studies were performed under laboratory conditions, so that further studies should be considered for the extension of the sludge-based biochar for in-field use.

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SCIENTIFIC EVENT: ISREIE 2019

Florentina MUNTEANU, Dana COPOLOVICI, Lucian COPOLOVICI*

"Aurel Vlaicu" University of Arad, Faculty of Food Engineering, Tourism and Environmental Protection; Institute for Research, Development and Innovation in Technical and Natural Sciences, Romania, 2 Elena Dragoi St., Arad, 310330, Romania

**Corresponding author: lucian.copolovici@uav.ro*

Abstract:

"Aurel Vlaicu" University of Arad organized on May 23rd -25th The 8th Edition of the International Symposium "Research and Education in Innovation Era" (ISREIE). Within the general program, 10 parallel sessions were carried out. In the present article, we have been focused on 3 sessions that were organized by the Faculty of Food Engineering, Tourism and Environmental Protection and the Institute for Research-Development-Innovation in Technical and Natural Sciences: Environmental Engineering, Plants, Environment and Human Health and Food Science, Applied Biotechnologies and Sustainability. In those three sessions were held three plenary, 13 oral scientific presentations and 16 posters.

Keywords: ISREIE 2019, international symposium, scientific presentations, posters.

Introduction

"Aurel Vlaicu" University of Arad organized in 1992-2004 the scientific communication session entitled "Scientific Communication Meeting". Since 2006, the International Symposium "Research and Education in Innovation Era" has been organized every two years. Starting with 2019, when this symposium has reached its eighth edition, this symposium is organized annually.

Within the general program, the diverse results from different fields (engineering, mathematics, technologies, design, sports, social sciences, etc) in 10 parallel sections were presented. This edition of the symposium was organized during May 23-25th 2019, at the "Aurel Vlaicu" University of Arad, in Arad, Romania (46°10′36″N 21°18′4″E).

The main objectives of this symposium are:

- Presentation, dissemination and promotion of scientific, artistic, sports and technological development research results obtained by researchers from "Aurel Vlaicu" University of Arad, from other national and international research institutes and universities;
- Knowledge of achievements and stage of development in the field of exact sciences, engineering, socio-economic sciences and humanities;
- The integration of the Romanian scientific community in the international scientific communities, as well as the increase of the visibility of its contribution to the international scientific patrimony and of the international recognition of the Romanian research;
- Stimulating innovation and raising awareness of the importance of applying the results of scientific research and technological development;
- Facilitating the meeting/networking of Romanian specialists with "top" foreign specialists from the research fields targeted by the symposium and with the representatives of the

economic environment in order to establish medium and long-term research partnerships;
- Raising public awareness of the importance and role in life and society of scientific research, inventions, innovations and technological development by promoting in the media and the Internet the latest and most important scientific achievements presented at the symposium;
- Marking the Centenary of the Romanian Union and promoting cultural heritage and identity

As usual there have been 3 sessions dedicated to research in natural and technical sciences which have been coordinated by Faculty of Food Engineering, Tourism and Environmental Protection (FIATPM) and the Institute for Research-Development-Innovation in Technical and Natural Sciences (ICDISTN).

GENERAL SESSION AND PARTICIPANTS

The symposium began with the opening ceremony of the works in which the Rector of "Aurel Vlaicu" University, Prof. Dr. Ramona Lile, and personalities from the local political and administrative personalities of Arad city addressed a welcome speech to the participants. Also, various greetings were addressed from the national and international universities through the representatives participating in the conference.

Fig. 1. Welcome speech from Prof. Dr. Mauro Centritto,

Sustainable Plant Protection Institute, National Research Council of Italy.

The number of participants was over 200 from 15 countries. FIATPM and ICDISTN had three prestigious guests from other countries at this symposium, namely: Acad. Prof. Dr. Ülo Niinemets, Estonian University of Life Sciences, Republic of Estonia, *Doctor honoris causa* of "Aurel Vlaicu" University; Prof. Dr. Mauro Centritto, Sustainable Plant Protection Institute, National Research Council of Italy (Fig. 1) and Prof. Dr. Artur Cavaco-Paulo, University of Minho, Portugal. Our guests also visited the new equipped laboratories for students from FIATPM.

Fig. 2 .Visits of FIATPM laboratories

PARALLEL SESSIONS

The symposium had 11 sessions, and the Faculty of Food Engineering, Tourism and Environmental Protection (FIATPM) and the Institute for Research-Development-Innovation in Technical and Natural Sciences (ICDISTN) organized three sessions, namely: (1) Environmental Engineering, (2) Plants, Environment and Human Health and (3) Food Science, Applied Biotechnologies and Sustainability. The first two took place on the first day and the third one on the second day.

The session *Environmental Engineering* was opened by the plenary presentation of

Prof. Dr. Artur Cavaco-Paulo entitled "Molecular Dynamics for Fiber and Cosmetic Applications" (Fig. 3a) and continued with three more oral presentations held by: Dr. Elisabeta Szerb ("Coriolan Dragulescu" Institute of Chemistry, Timisoara, Fig. 3b), Lect. Dr. Madalina Tudorache (University of Bucharest, Fig. 3 c) and Prof. Dr. Habil. Dana Copolovici ("Aurel Vlaicu" University, Fig. 3d).

Fig. 3. Parallel session presentations.

During the *Plants, Environment and Human Health* session, two plenary presentations on Agriculture Under Global Change were presented by Prof. Dr. Ülo Niinemets (Fig. 4a) and Evolutionary Development of Stomatal Control of Photosynthesis and Climate Change by Prof. Dr. Mauro Centritto (Fig. 4c). There were also oral presentations by Prof. Dr. Habil. Alina Zamfir (Fig. 4b), Prof. Dr. Habil. Florentina Munteanu and Prof. Dr. Habil. Lucian Copolovici (the latest from "Aurel Vlaicu" University) on various topics of current interest.

Fig. 4. Parallel session presentations

During the *Food Science, Applied Biotechnologies and Sustainability* session, various oral presentations were presented on topics of interest to the audience regarding Developing Teaching and Learning Resources, Food industry, Implementation of European Structural Funds Projects by Assoc. Prof. Dana Radu, Lect. Dr. Claudia Muresan, Lect. Dr. Sergiu Palcu and Lect. Dr. Sabin Chis. Two papers on the determination of fatty acids from wastes and the antibiotic resistance were presented by students Ioana Moldovan ("Aurel Vlaicu" University) and Silvana-Adriana Ardelean ("Lucian Blaga" University of Sibiu), respectively. Also, various products obtained in FIATPM laboratories were tasted (Fig. 5).

Fig. 5. Parallel session presentations and coffee breaks.

The poster session included a number of 16 posters from different fields including the food industry, waste recovery, monitoring of environmental parameters.

CONCLUSIONS

Through the complex fields approached, inter- and trans-disciplinary of maximum importance for ERA (European Research Area), through the parallel sessions addressed to both humanities and exact sciences and engineering and through the involvement of the economic environment, ISREIE 2019 is one of the scientific manifestation with the widest thematic spectrum, which makes it unique from a national point of view and among the few of its kind at the international level. Moreover, we believe that this symposium is the only one that through its objectives and the approached themes, education and research are equally represented. This is in line with modern trends at European and international level, and supports the current concept promoted by the European Union, according to which, in the age of innovation, in a knowledge-based society, education and research must be considered complementary, inseparable branches.

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