Scientific report
(Contract number TE 158/21.10.2020)

Project: Research regarding the bread quality improvement by using flours from germinated leguminous

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The research project aims to analyze the effect of the flour addition from germinated legumes (chickpea, lentils, soybeans, lupins, beans) in a malted form obtained through lyophilization on the bread quality from the technological and nutritional point of view. In this regard, it will be evaluated the quality and the composition of the raw materials used, the modifications of the rheological properties induced by the addition of flour from legumes in a germinated form in wheat flour, the dough microstructure and the quality of the bakery products obtained.

The main objectives of the project TE158/2020 during the entire period of the project 1/11/2020-31/10/2022 were:

O1. Physico-chemical characteristics of base materials that will be used in the experiments: wheat flour and legumes;

O2. Production and physico-chemical characteristics of germinated flours;

O3. Physico-chemical characteristics of composite flours;

O4. Evaluation of rheological properties of composite flours;

O5. Microstructure analysis of dough from composite flours;

O6. Evaluation of the bread products quality obtained from composite flours.

The activities related to these objectives with specific results during the entire period of the project 1/11/2020-31/10/2022 according to the ***Annex II of Contract*** No. TE158/2020 was:

A1.1. Technological characterization of wheat flour that will be used in experiments: moisture, ash, wet gluten content, index of gluten deformation, falling number index. The following results will be obtained: moisture, ash, wet gluten content, index of gluten deformation, falling number index (stage 1 of the project);

A2.1. Physico-chemical characterization of wheat flour: proteins, lipids, minerals content, and amino acids content. The following results will be obtained: determination of the proteins, lipids, minerals content and amino acids content of the wheat flour that will be used in experiments (stage 2 of the project);

A2.2. Physico-chemical characterizations of legumes that will be uded in experiments: protein, lipids, mineral content and amino acids content. The following results will be obtained: determination of the proteins, lipids, minerals content and amino acids content of the legumes flour that will be used in experiments (stage 2 of the project) ;

A2.3. The production (establishing the working protocol) of germinated flours from legumes: lentil, chickpea, soybean, lupin, bean. The following results will be obtained: obtaining of the germinated legumes flour from lentil, chickpea, soybean, lupin, beans (stage 2 of the project);

A2.4. Physico-chemical characterizations of germinated legumes flour obtained: humidity, ash, acidity, proteins, lipids, amino acids and mineral content. The following results will be obtained:

determination of the physico-chemical of germinated legumes flour such as humidity, ash, acidity, proteins, lipids, amino acids and mineral content (stage 2 of the project);

A2.5. Microbiological characterization of germinated legumes flour obtained: yeast molds, mycotoxins. The following results will be obtained: determination of the microbiological content of the flours obtained from germinated legumes yeast, molds, and mycotoxins (stage 2 of the project);

A2.6. Physico-chemical characterization of the composite flours obtained (mix of wheat flour and one type of germinated flours from lentil, chickpea, soybean, lupin, bean): humidity, ash, acidity, proteins, lipids, amino acids and mineral content. The following results will be obtained: determination of the physico-chemical characteristics of the composite flours (mix of wheat flour and one type of germinated flours from lentil, chickpea, soybean, lupin, bean): humidity, ash, acidity, proteins, lipids, amino acids and mineral content (stage 2 of the project);

A2.7. Empirical dough rheological properties characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition) during mixing. The following results will be obtained: determination of the empirical dough rheological properties characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition) during mixing (stage 2 of the project);

A2.8. Empirical dough rheological properties characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition) during extension. The following results will be obtained: determination of the empirical dough rheological properties characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition) during extension (stage 2 of the project);

A2.9. Empirical dough rheological properties characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition) during fermentation. The following results will be obtained: determination of the empirical dough rheological properties characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition) during fermentation (stage 2 of the project);

A2.10. Dissemination of research results. The following results will be delivered: publication of at least 1 article ISI, proposed to OSIM of minimum 3 patents, participation to at least 2 conferences (1 with the industrial participation) – period up to December 2021 (stage 1 and stage 2 of the project);

A3.1. Fundamental dough rheological properties characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition). The following results will be obtained: determination of the fundamental dough rheological properties characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition) (stage 3 of the project);

A3.2. Microstructure characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean). The following results will be obtained: determination of the microstructure characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean) (stage 3 of the project);

A3.3. Description of the technological process of bread-making from composite flours. The bread from different composite flours will be obtained (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean) (stage 3 of the project);

A3.4. Evaluation of physical characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean). The following results will be obtained: physical characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean): porosity, elasticity, loaf volume (stage 3 of the project);

A3.5. Evaluation of microstructural characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean). The following results will be obtained: microstructural characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean) - (stage 3 of the project);

A3.6. Evaluation of sensorial characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean). The following results will be obtained: sensorial characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean) - (stage 3 of the project);

A3.7. Evaluation of textural characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean). The following results will be obtained: textural characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean) - (stage 3 of the project);

A3.8. Evaluation of color characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean). The following results will be obtained: color characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean) - (stage 3 of the project);

A3.9. Evaluation of nutritional characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean). The following results will be obtained: nutritional characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean): ash, acidity, protein, fat content, mineral content, amino acid content - (stage 3 of the project);

A3.10. Dissemination of research results. The following results will be delivered: publication of at least 2 articles ISI, participation to at least 1 conference in the stage 3 of the project.

RESULTS OBTAINED

1. Working methods and the devices used

The working methods were grouped as following:

1.1. Methods used for the evaluation of the physical-chemical properties of flours from wheat, legumes and germinated legumes;

1.2. Methods used for the evaluation of the dough rheological properties of the mix from composite flours;

1.3. Methods used for the evaluation of the dough microstructure of the mix from composite flours;

1.4. Methods used for the evaluation of the bread quality.

1.1. Methods used for the evaluation of the physical-chemical properties of flours from wheat and legumes

The research concerning the determination of the physical-chemical properties for wheat flour, legumes and germinated legumes (lentil, chickpea, soybean, lupin, bean) single and in mix with wheat flour were made by the following methods:

- moisture content determination by oven drying, according to SR 90:2007 (for wheat flour), AACC International Approved Methods 44-15.02 or ICC 110/1;
- ash content determination according to SR 90:2007 (for wheat flour), AACC Method 08-01.01 or ICC 104/1;
- protein content determination using Kjeldahl device according to AACC Method 46-12.01 or ICC 105/2;
- pH according to AACC Method 02-52.01;
- acidity determination according to SR 90:2007;
- fat content through Soxhlet method according to AACC Method 30-25.01 or ICC 136;

- yeast and molds according to SR ISO 7954:2001, *Bacillus cereus* according to SR EN ISO 7932-2003:2005 and mycotoxins by using an ELISA kit (Prognosis Biotech, Larissa, Greece) for germinated legumes flours obtained;

- the mineral content of the samples were analyzed by flame atomic absorption spectrometry (FAAS) (AA-6300 Shimadzu, Kyoto, Japan) equipped with air-acetylene flame. Hollow cathode lamps of Na, Mg, Fe and Zn were used. In total, 10 g with an accuracy of 10 mg from each sample was used for calcination. The calcination temperature was increased with a maximum speed of 50◦C/h up to 450 ◦C. The calcination time was 8 h. Ash digestion was performed using 10 mL 0.1 mol/L nitric acid (HNO3) (Sigma-Aldrich/Merck, Darmstadt, Germany) on a hot plate. After digestion of the ash samples, up to 50 mL was filled with bidistilled and deionized water. Standard solutions of Na, Mg, Fe and Zn (Sigma-Aldrich/Merck, Darmstadt, Germany) were used and diluted as necessary to obtain working standards. In order to eliminate the risk of contamination, all glassware was washed after each use with HNO_3 solution and rinsed with bidistilled and deionized water.

- The amino acids determination was done by using the EZ:Faast kit (Phenomenex, Germany) and consisted of a solid phase extraction step and a derivatization and liquid/liquid extraction step. The solid phase extraction was performed via a sorbent packed tip that bended amino acids while allowing interfering compounds to flow through (Phenomenex, 2005). Amino acids on sorbent were then extruded into the sample vial and quickly derivatized with reagent at room temperature in aqueous solution. Derivatized amino acids concomitantly migrate to the organic layer for additional separation from interfering compounds (Phenomenex, 2005). Organic layer was then removed, evaporated, and suspended again in dissolution solvent and analyzed on a Shimadzu GC/MS system (GC MS-QP 2010 Plus, Shimadzu, Kyoto, Japan) with a Zebron ZB-AAA GC column;

- Falling number of the wheat flour and mix flours (wheat flour with different levels of germinated flour addition in single or different combinations) according to ICC 107/1 method;

1.2. Methods used for the evaluation of the dough rheological properties of the mix from composite flours.

The dough rheological properties of the mix from the composite flours were made by using the Alveo Consistograph (Alveograph and Consistograph part), Rheofermentometer and dynamic rheometer devices by the following methods:

- The dough empirical rheological properties druing mixing of the mix from the composite flours determined with the Alveo Consistograph (Chopin Technologies, Cedex, France) device (Consistograph part) were made according to ICC 171 and AACC 54–50 approval. The fallowing characteristics were determined: water absorption capacity (WA), maximum pressure (PrMax), tolerance to kneading (Tol), consistency of the dough after 250 s (D250) and consistency of the dough after 450 s (D450);

- The dough empirical rheological properties druing extension of the mix from the composite flours were determined with the Alveo Consistograph (Chopin Technologies, Cedex, France) device (Alveograph part) according to ICC 121, AACC 54–30A and ISO 5530/4 approval. The fallowing characteristics were determined: maximum pressure (P), dough extensibility (L), index of swelling (G), baking strength (W) and configuration ratio of the Alveograph curve (P/L);

- The dough empirical rheological properties during fermentation of the mix from the composite flours were determined with the Rheofermentometer device (Chopin Rheo, type F4, Villeneuve-La-GarenneCedex, France) according to AACC89– 01.01 approval. The fallowing characteristics were determined: total CO_2 volume production (VT, mL), maximum height of gaseous production (H'm, mm), volume of the gas retained in the dough at the end of the test (VR, mL) and retention coefficient (CR, %);

- The dough fundamental rheological properties of the mix from the composite flours were determined with the HAAKE MARS 40 rheometer device (Termo-HAAKE, Karlsruhe, Germany). For this purpose, a gap of 2 mm and a plate system of 40 mm were used. Taking into account the optimal value of the water absorption capacity, the dough ingredients were mixed in the AlveoConsistograph tank, and then, the sample was placed between rheometer plates and rested before analysis for 5 min for relaxation. The tests performed on the rheometer were: the frequency sweep test (in a range of linear viscoelasticity) and during heating (at a heating rate of 4 ◦C per min at

a frequency of 1 Hz and a fixed strain of 0.001). The storage modulus (*G'*), loss modulus (*G"*) and loss tangent (*tan δ*) were determined.

1.3. Methods used for the evaluation of the dough microstructure of the mix from composite flours.

The dough microstructure of the mix from the composite flours were determined with the Motic AE 31 (Motic, Optic Industrial Group, Xiamen, China) equipped with LWD PH 203 catadioptric objectives (N.A. 0.4). For this purpose, a thin portion was cut from the dough samples and immersed in a fixing solution composed of 1% rhodamine B and 0.5% fluorescein (FITC) in 2-methoxyethanol for at least 1 h. Fluorescein and rhodamine B were used as specific fluorescent dyes to detect proteins (rhodamine B) and starch (fluorescein) in the dough samples. After immersing the dough in the fixing solution, EFLM images were obtained and then analyzed using ImageJ (v. 1.45, National Institutes of Health, Bethesda, MD, USA) software.

1.4. Methods used for the evaluation of the bread quality obtained from composite flours.

The bread quality characteristics obtained from composite flours (physical, microstructural, sensorial, textural, color, nutritional) were determined by the following methods:

- The bread physical characteristics (loaf volume by using the Fornet device, porosity, elasticity) were made according to the the standard method SR 91:2007 and AACC Method 10–05.01;
- The bread microstructural images were made the Motic SMZ-140 stereo microscope (Motic, Xiamen, China). Fro this purpose, a resolution of 2048x1536 pixels with a 20x objective was used;
- The bread sensorial characteristics (appearance, color, aroma, taste, smell, texture, and global acceptability) was made using a 9-point hedonic scale from 1 to 9 in which 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely with semitrained judges from Stefan cel Mare University;
- The bread textural characteristics (firmness, gumminess, cohesiveness, and resilience) were determined using an TVT-6700 texturometer device (Perten Instruments, Hägersten, Sweden). For the determination, the texturometer used was equipped with a 10 kg load cell. Slices of bread of 50 mm height were subjected to two compression cycles to up to 20% of their initial height. The analysis was conducted using a 45 mm cylindrical probe. The protocol used was: a trigger force of 5 g, a speed of 1.0 mm/s, and a recovery period between compressions of 15 s;
- The bread color characteristics (for crumb and crust of the bread samples) were determined using a Konica Minolta CR-400 colorimeter (Tokyo, Japan). With the help of this colorimeter, the values for the following parameters were measured: *L** (darkness/brightness), *b** (shade of blue/yellow), and *a** (shade of red/green);
- The bread nutritional characteristics (ash, acidity, protein, fat content, mineral content, amino acid content) was determined with the same methods presented to the 1.1. methods.

2. Results and discussions

For the research objectives proposed in **Annex II of Contract** No. TE158/2020 during the entire period of the project 1/11/2020-31/10/2022 the following results were obtained:

Objectives (Objective Name)	Associated activities	Disseminations results
O1. Physico-chemical characteristics of base materials that will be used in the experiments: wheat flour and legumes	A1.1. Technological characterization of wheat flour that will be used in experiments: moisture, ash, wet gluten content, index of gluten deformation, falling number index.	The data about the base materials used in this project were presented in different articles (8 ISI, 2 BDI), 12 papers presented to different
	A2.1. Physico-chemical characterization of wheat flour: proteins, lipids, minerals content, and amino acids content.	
	A2.2. Physico-chemical characterizations of legumes that will be uded in experiments: protein, lipids, mineral content and amino acids content.	

	A2.4. Physico-chemical characterizations of germinated legumes flour obtained: humidity, ash, acidity, proteins, lipids, amino acids and mineral content.	conferences.
	A2.5. Microbiological characterization of germinated legumes flour obtained: yeast molds, mycotoxins.	
O2. Production and physico-chemical characteristics of germinated flours	A2.3. The production (establishing the working protocol) and physico-chemical characteristics of germinated flours from legumes: lentil, chickpea, soybean, lupin, bean.	The data about the production of germinated flours from legumes were published in 6 ISI articles (Q1 and Q2), 3 patent applications filed submitted for evaluation to OSIM, 7 papers presented to different conferences.
O3. Physico-chemical characteristics of composite flours	A2.6. Physico-chemical characterization of the composite flours obtained (mix of wheat flour and one type of germinated flours from lentil, chickpea, soybean, lupin, bean): humidity, ash, acidity, proteins, lipids, amino acids and mineral content.	The data about physico-chemical characterization of the composite flour were published in 2 BDI articles
O4. Evaluation of rheological properties of composite flours	A2.7. Empirical dough rheological properties characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition) during mixing.	The data about dough rheological properties obtained from composite flours were presented in 6 ISI articles (Q1 and Q2), 5 papers presented to different conferences.
	A2.8. Empirical dough rheological properties characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition) during extension.	
	A2.9. Empirical dough rheological properties characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition) during fermentation.	
	A3.1. Fundamental dough rheological properties characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition) .	
O5. Microstructure analysis of dough from composite flours	A3.2. Microstructure characterization of dough obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean).	The data about dough microstructure obtained from composite flours were published in 6 ISI articles (Q1 and Q2).
O6. Evaluation of the bread products quality obtained from composite flours	A3.3. Description of the technological process of bread-making from composite flours.	The data about the technological process of bread-making from composite flours and quality of the bread obtained were published in 6 ISI articles (Q1 and
	A3.4. Physical characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean): porosity, elasticity, loaf volume	
	A3.5. Microstructural characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean)	

	A3.6. Sensorial characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean)	Q2), 2 patent applications filed submitted for evaluation to OSIM, 6 papers presented to different conferences.
	A3.7. Textural characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean)	
	A3.8. Color characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean)	
	A3.9. Nutritional characteristics of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean): ash, acidity, protein, fat content, mineral content, amino acid content	
Dissemination of research results Should be delivered (Activity 2.10): publication of at least 1 article ISI, proposed to OSIM of minimum 3 patents, participation to at least 2 conferences (1 with the industrial participation). **Achieved:** - 6 articles published in ISI journals from which 5 in Q1/Q2 category; - 1 BDI article published (SCOPUS indexed), under ISI WEB evaluation - 3 patents applications filed submitted for evaluation to OSIM; - 8 papers presented to different 8 conferences (1 with the industrial participation - RO.aliment SHOW, fifth edition, 17-21 May, oral presentation– after the presentation Millbo company contact us for a collaboration);	**Obtained results (during the entire period of the project 1/11/2020-31/10/2022):** ***I. Articles published in journals indexed/quoted ISI*** 1. Atudorei D, Codină G.G., 2020, *Perspectives on the use of germinated legumes in the bread making process, a review*, Applied Sciences, impact factor 2.838, ***Q2 journal***, accession number: WOS:000580385400001 Available online: https://www.mdpi.com/2076-3417/10/18/6244 2. Atudorei D, Stroe S.G., Codină G.G., 2020, Physical, physiological and minerals changes of different legumes types during the germination process, Ukranian Food Journal, 9 (4), 844-863, Web of Science, accession number: WOS: 000616627300008 Available online: http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202020%20V.9%20Is.4.pdf 3. Atudorei D, Stroe S.G., Codină G.G., 2021, Impact of germination on the microstructural and physicochemical properties of different legume types, Plants-Basel, impact factor 4.658, ***Q1 journal***, accession number: WOS: 000634093800001 Available online: https://www.mdpi.com/2223-7747/10/3/592 4. Atudorei D, Atudorei O, Codină G.G., 2021, Dough rheological properties, microstructure and bread quality of wheat-germinated bean composite flour, Foods, impact factor 5.561, ***Q1 journal***, accession number: WOS: 000676853800001 Available online: https://www.mdpi.com/2304-8158/10/7/1542 5. Ungureanu-Iuga M., Atudorei D., Codină G.G., Mironeasa S., 2021, Rheological approaches of wheat flour dough enriched with germinated soybean and lentil, Applied Sciences, impact factor 2.838, **Q2 journal,** accession number: WOS: 000742694600001 Available online: https://www.mdpi.com/2076-3417/11/24/11706 6. Atudorei D., Ungureanu-Iuga M., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000735685200001 7. Atudorei D., Ropciuc S., Codină G.G., 2022, Possibilities to use germinated lupine flour as an ingredient in breadmaking to improve the final product quality, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000775367400001 Available online: https://www.mdpi.com/2073-4395/12/3/667 8. Atudorei D., Atudorei O., Codină G.G., 2022, The impact of germinated chickpea flour addition on dough rheology and bread quality, Plants-Basel, impact factor 4.658, **Q1 journal**, accession number: WOS: 000794770500001 Available online: https://www.mdpi.com/2223-7747/11/9/1225 9. Atudorei D., Mironeasa S., Codină G.G., 2022, Effects of germinated lentil flour on dough rheological behavior and bread quality, Foods, impact factor 5.561, **Q1 journal,** accession number: WOS: 000866785800001	

Should be delivered (Activity 3.10): publication of at least 2 article ISI, participation to at least 1 conference **Achieved:** - 3 articles published in ISI journals (Q1 category); - 1 BDI article accepted for publication; - 4 papers presented to different international conferences.	Available online: https://www.mdpi.com/2304-8158/11/19/2982 ***II. Articles published in journals indexed BDI*** 1. Codină G.G., Iuga M., Stroe S.G., Mironeasa S., Chemical characterization of wheat-germinated legumes composite flours, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, Volume 21, Issue 6.1, Pages 79 – 87, DOI: 10.5593/sgem2021/6.1/s25.11 – SCOPUS indexed 2. Ursachi F., Atudorei D., Ungureanu-Iuga M., Codină G.G., Amino acids composition of wheat-germinated legumes composite flours, accepted for publication in Scientific Bulletin. Series F. "Biotechnologies", ISSN 2285-1364, International Database Indexing: Index Copernicus, CABI, DOAJ, Ulrich's Periodicals Directory (ProQuest), PBN, Cite Factor (Academic Scientific Journals), Scipio, OCLC (WorldCat), Research Bible, Google Scholar. ***III. Patent applications filed submitted for evaluation to OSIM*** 1. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., Functional flour from germinated legumes for baking and process for obtaining it A/00570/2021 has been title changed according to OSIM recommendations to ***Process for obtaining a functional flour for bread-making obtained from germinated legumes*** 2. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., ***Functional white bread with an increased protein value by adding germinated legumes and the process of obtaining it***, A/00569 3. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., Nutritionally enriched white bread with the addition of flour from germinated legumes with high enzymatic activity and process for obtaining it, A/00568/2021 has been title changed according to OSIM recommendations to ***Process for obtaining a bread-type food product nutritionally enriched with germinated legumes flour addition and the process for obtaining flour from the mix of germinated legumes*** ***IV. Conference participations*** 1. Atudorei D., Golea C., Physical and physiological modifications of different legumes types during the germination process, oral presentation to the 9th Edition for International Conference for Students-Student in Bucovina, 18 December 2020, Suceava, prize III to Ph.D. Research students section Available online: http://fia-old.usv.ro/fiajournal/Student_in_Bucovina_2020/ 2. Atudorei D., Atudorei O., Codină G.G., Physico-chemical and consumer acceptance of white bread as affected by germinated bean flour addition, 87 International scientific conference of young scientist and students "Youth scientific achievements to the 21st century nutrition problem solution", 15–16 April, 2021 Available online: http://conferencenuft.ho.ua/Books%20of%20abstracts/2021/Part%201.pdf 3. Atudorei D., Improving the quality of bakery products by using germinated legume flour, RO.aliment SHOW, fifth edition, 17-21 may, oral presentation on 20 may during Backery products & Swets & Alternative products section (invited representatives of the food industry, academia, consumers) Available on-line: https://www.roaliment.ro/academy/event/ro-aliment-show-2021-fost-ingredients-show/ 4. Atudorei D., Atudorei O., Codină G.G. The effect of germinated beans on wheat dough rheology, The 16th International Conference of Constructive Design and Technological Optimization in Machine Building Field OPROTEH 2021, 25-27 May, Bacău, Romania Available online: http://oproteh.ub.ro/ 5. Iuga-Ungureanu M., Atudorei D., Codină G.G., Mironeasa S., Chemical characterization of wheat-germinated legumes composite flours, XXIth International Multidisciplinary Scientific GeoConference Surveying, Geology and Mining, Ecology and Management – SGEM 2021 Available on-line: https://www.sgem.org/ 6. Atudorei D., Codină G.G., Dough rheological properties as affected by addition of germinated chickpea flour, 8th Edition of the International Conference, 5th November 2021 Biotechnologies, present and Perspectives Available on-line: https://fiajournal.usv.ro/conference2021/

	7. Atudorei D., Codină G.G., The effect of germinated lentil flour on bread making, 8th Edition of the International Conference, 5th November 2021 Biotechnologies, present and perspectives Available on-line: https://fiajournal.usv.ro/conference2021/ 8. Atudorei O., Atudorei D., The effect of the addition of germinated soybean flour on the rheological properties of wheat flour dough, Annual student scientific communication session, november 2021, Facultatea de Ingineria Mediului și Știința Alimentelor, Târgoviște 9. Atudorei D., Atudorei O., Codină G.G., Nutritional impact of the germinated bean flour addition in the recipe for making white wheat bread, 88 International scientific conference of young scientist and students "Youth scientific achievements to the 21st century nutrition problem solution", April-May, Kyiv, NUFT, 2022 Available on-line: http://conferencenuft.ho.ua/Books%20of%20abstracts/2022/Part%201.pdf 10. Codină G.G., Atudorei D., Ungureanu-Iuga M., Ursachi F., Amino acids composition of wheat-germinated legumes composite flours, The International conference agriculture for life, life for agriculture, June 2-4, 2022, Bucharest, Romania 11. Codină G.G., Atudorei D., Ungureanu-Iuga M., Ursachi F., Stroe S.G., Effects of germinated lupine and chickpea flour addition on nutritional quality of white wheat bread, 4th World conference on sustainable life sciences, 1-7 August, Istanbul, Turkey, 2022 Available on-line: https://www.wocols.com/ 12. Codină G.G., Atudorei D., Ursachi F., Stroe S.G., Ungureanu-Iuga M., Nutrition value of white wheat bread supplemented with soybean and lentil germinated flour, European Biotechnology Congress 2022, 5-7 October, Prague, Czechia Available on-line: http://eurobiotech2022.eu/

O1. Physico-chemical characteristics of base materials that will be used in the experiments: wheat flour and legumes* (*activities A1.1., A2.1, A2.2, A2.4, A.2.5)

In this research project were used a white wheat flours obtained from the 2020 processing grain harvest. The wheat flour were without any additive or enzymatic corrections. The wheat flour used as base material in our research was of a strong quality for bread making and a low α amylase activity according to it falling number value (350 s). In order to establish to this flour, several wheat flour samples were analyzed from companies that are not using additives or enzymatic corrections in the mill. In Romania wheat flours are vary from one year to another and that's way we find with some difficulty a wheat flour of a strong quality for bread making and a low α amylase activity. Otherwise, if we had not found such a wheat flour quality, we would have been using in our research a wheat flour of a very good quality for bread making and a low α amylase activity.

The physical-chemical characteristics of the wheat flour (**activity A1.1 –stage 1**) used as the base material were the following: 14.6% moisture, 0.66% ash content, 12.3% protein, 1.12% fat, 30.4% wet gluten and 3-mm gluten deformation index. The falling number of the wheat flour was 350 s. According to the data obtained, the wheat flour was a white one, of a very strong quality for bread making and had a low α amylase activity. The data regarding the wheat flour quality were presented in 6 articles and 6 papers presented to different conferences. For example, this data may be seen to the article below:

Atudorei D, Atudorei O, Codină G.G., 2021, *Dough rheological properties, microstructure and bread quality of wheat-germinated bean composite flour*, Foods, impact factor 5.561, ***category Q1***, accession number: WOS: 000676853800001

Available online: https://www.mdpi.com/2304-8158/10/7/1542

The rest of the data that will be discussed further correspond to the period January 2021-October 2022 (stage 2 and 3 of the project).

The physico-chemical characterizations of legumes (lentil, chickpea, soybean, lupin, bean) such as humidity, proteins, fat (A2.2) were presented in 3 articles and 4 papers presented to different conferences. The articles in which this data may be seen are:

1. Atudorei D, Stroe S.G., Codină G.G., 2020, *Physical, physiological and minerals changes of different legumes types during the germination process*, Ukranian Food Journal, 9 (4), 844-863, Web of Science, accession number: WOS: 000616627300008

Available online:
http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202020%20V.9%20Is.4.pdf

2. Atudorei D, Stroe S.G., Codină G.G., 2021, *Impact of germination on the microstructural and physicochemical properties of different legume types*, Plants-Basel, impact factor 4.658 , ***category Q1***, accession number: WOS: 000634093800001

Available online: https://www.mdpi.com/2223-7747/10/3/592

3. Codină G.G., Iuga M., Stroe S.G., Mironeasa S., Chemical characterization of wheat-germinated legumes composite flours, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, Volume 21, Issue 6.1, Pages 79 – 87, DOI: 10.5593/sgem2021/6.1/s25.11 – SCOPUS indexed

More, the data about hectolitre weight, viability and germination energy of the legumes used may be seen in the published article:

Atudorei D, Stroe S.G., Codină G.G., 2020, *Physical, physiological and minerals changes of different legumes types during the germination process*, Ukranian Food Journal, 9 (4), 844-863, Web of Science, accession number: WOS: 000616627300008

Available online:http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202020%20V.9%20Is.4.pdf

The data about pH, acidity, the mineral content of the wheat flour and the legumes used (A2.1, A.2.2) may be seen in the articles below:

Codină G.G., Iuga M., Stroe S.G., Mironeasa S., Chemical characterization of wheat-germinated legumes composite flours, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, Volume 21, Issue 6.1, Pages 79 – 87, DOI: 10.5593/sgem2021/6.1/s25.11 – SCOPUS indexed

The data about the physico-chemical characterizations of legumes and germinated legumes flour obtained (A2.2., A2.4): humidity, ash, acidity, proteins, lipids, amino acids and mineral content may be seen in the article bellow:

Atudorei D, Stroe S.G., Codină G.G., 2021, *Impact of germination on the microstructural and physicochemical properties of different legume types*, Plants-Basel, impact factor 4.658, ***category Q1***, accession number: WOS: 000634093800001

Available online: https://www.mdpi.com/2223-7747/10/3/592

More, the mineral content of the legumes samples in a raw and germinated form has also been published in the below article:

Atudorei D, Stroe S.G., Codină G.G., 2020, *Physical, physiological and minerals changes of different legumes types during the germination process*, Ukranian Food Journal, 9 (4), 844-863, Web of Science, accession number: WOS: 000616627300008

Available online:http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202020%20V.9%20Is.4.pdf

The amino acids content of the legumes samples in a raw and germinated have been presented in the below article (accepted for publication):

Ursachi F., Atudorei D., Ungureanu-Iuga M., Codină G.G., Amino acids composition of wheat-germinated legumes composite flours, accepted for publication in Scientific Bulletin. Series F. "Biotechnologies", ISSN 2285-1364, International Database Indexing: Index Copernicus, CABI, DOAJ, Ulrich's Periodicals Directory (ProQuest), PBN, Cite Factor (Academic Scientific Journals), Scipio, OCLC (WorldCat), Research Bible, Google Scholar

From the amino acids point of view, according to the data obtained (data which have been accepted for publication) the wheat flour presented lower levels of essential amino acids compared to the legumes flour. Also the legumes flour in a germinated form (after 4 days of germination) presented higher levels of essential amino acids compared to the non germinated legumes. For germinated legumes flour the highest levels for essential amino acids were recorded for histidine, followed by valine and threonine while the lowest level were recorded for tryptophan. The highest amounts for essential amino acids from germinated legumes were recorded for germinated lentil fallowed by germinated bean. Also non-essential amino acids content were determined for wheat flour, legumes and germinated legumes (after 4 days) for the fallowing: glutamic acid, glycine, proline, alanine, serine, aspartic acid e.g. In general, from the non-essential amino acids the highest amounts were recorded for the aspartic acid fallowed by serine and glutamic acid. The highest

amounts for aspartic acid were recorded for germinated bean and the highest amount for serine for germinated soybean. Regarding the wheat flour it presented high amounts for essential amino acids such as histidine, isoleucine, methionine, fenilalanine, tryptofan, valine. From non-essential amino acids it presented high amount but lower than those recorded for essential amino acids for serine and aspartic acid. For wheat flour the highest amount obtained were those for non-essential amino acids glutamic acid of which value were higher than those obtained for legumes and germinated legumes flours.

The data regarding the microbiological characterization of germinated legumes flour obtained: yeast molds, mycotoxins may be seen in 3 articles. In this articles were reported yeast and molds, *Bacillus cereus* and as mycotoxins aflatoxin, ochratoxin and zearalenone – for bean in article 1 below, for soybean and lentil – in article 2 below, for chickpea an lupin in article 3 below:

1. Atudorei D, Atudorei O, Codină G.G., 2021, *Dough rheological properties, microstructure and bread quality of wheat-germinated bean composite flour*, Foods, impact factor 5.561, ***category Q1***, accession number: WOS: 000676853800001

Available online: https://www.mdpi.com/2304-8158/10/7/1542

2. Ungureanu-Iuga M., Atudorei D., Codină G.G., Mironeasa S., 2021, Rheological approaches of wheat flour dough enriched with germinated soybean and lentil, Applied Sciences, impact factor 2.838, **Q2 journal,** accession number: WOS: 000742694600001

Available online: https://www.mdpi.com/2076-3417/11/24/11706

3. Atudorei D., Ungureanu-Iuga M., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000735685200001

Available online: https://www.mdpi.com/2073-4395/11/12/2588

According to the data obtained, the germinated legumes flours were from the microbiological point of view in the limits range recommended by the European Union and, therefore, may be used as ingredients in food products.

All the results established to the objective O1 and activities A1.1, A2.1, A2.2, A2.4, A2.5 have been achieved and published (or accepted for publication – 1 article). The data may be seen in the published/accepted for publication articles available in the UEFISCDI system – the articles in extenso are loaded where the results obtained are discussed in a very extensive way. The only unpublished data are those related to the amino-acids content of the base raw materials, data that have been accepted for publication (the article accepted for publication is loaded in the UEFISCDI system). In addition to what was etsablished in the project activities form O1 objective ***more data were obatined*** such as scanning electron microscope (SEM) images for legumes and germinated legumes microstructure and Fourier transform infrared spectroscopic (FT-IR) spectra of legumes during germination as it may be seen from the data of the article bellow:

Atudorei D, Stroe S.G., Codină G.G., 2021, *Impact of germination on the microstructural and physicochemical properties of different legume types*, Plants-Basel, impact factor 4.658, ***category Q1***, accession number: WOS: 000634093800001

Available online: https://www.mdpi.com/2223-7747/10/3/592

Also, the physico-chemical characteristics of a mix of germinated legumes flours of 40% germinated red lentil, 15% germinated white sweet lupine, 15% germinated soy, 15% germinated bean and 15% germinated chickpea were presented in the patent application filed submitted for evaluation to OSIM bellow:

Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., *Functional flour from germinated legumes for baking and process for obtaining it*, A/00570

In ***conclusion***, the data related to the ***O1 objective (activities A1.1, A2.1, A2.2, A2.4, A2.5)*** have been published in the fallowing papers, presented to the fallowing conferences:

I. Articles published in journals indexed/quoted ISI

1. Atudorei D, Stroe S.G., Codină G.G., 2020, *Physical, physiological and minerals changes of different legumes types during the germination process*, Ukranian Food Journal, 9 (4), 844-863, Web of Science, accession number: WOS: 000616627300008

Available online:http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202020%20V.9%20Is.4.pdf

2. Atudorei D, Stroe S.G., Codină G.G., 2021, *Impact of germination on the microstructural and physicochemical properties of different legume types*, Plants-Basel, impact factor 4.658, ***category Q1***, accession number: WOS: 000634093800001

Available online: https://www.mdpi.com/2223-7747/10/3/592

3. Atudorei D, Atudorei O, Codină G.G., 2021, *Dough rheological properties, microstructure and bread quality of wheat-germinated bean composite flour*, Foods, impact factor 5.561, ***category Q1***, accession number: WOS: 000676853800001

Available online: https://www.mdpi.com/2304-8158/10/7/1542

4. Ungureanu-Iuga M., Atudorei D., Codină G.G., Mironeasa S., 2021, Rheological approaches of wheat flour dough enriched with germinated soybean and lentil, Applied Sciences, impact factor 2.838, **Q2 journal,** accession number: WOS: 000742694600001

Available online: https://www.mdpi.com/2076-3417/11/24/11706

5. Atudorei D., Ungureanu-Iuga M., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000735685200001

Available online: https://www.mdpi.com/2073-4395/11/12/2588

6. Codină G.G., Iuga M., Stroe S.G., Mironeasa S., Chemical characterization of wheat-germinated legumes composite flours, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, Volume 21, Issue 6.1, Pages 79 – 87, DOI: 10.5593/sgem2021/6.1/s25.11 – SCOPUS indexed

7. Ursachi F., Atudorei D., Ungureanu-Iuga M., Codină G.G., Amino acids composition of wheat-germinated legumes composite flours, accepted for publication in Scientific Bulletin. Series F. "Biotechnologies", ISSN 2285-1364, International Database Indexing: Index Copernicus, CABI, DOAJ, Ulrich's Periodicals Directory (ProQuest), PBN, Cite Factor (Academic Scientific Journals), Scipio, OCLC (WorldCat), Research Bible, Google Scholar.

II. Conference participations

1. Atudorei D., Golea C., *Physical and physiological modifications of different legumes types during the germination process*, oral presentation to the 9th Edition for International Conference for Students-Student in Bucovina, 18 December 2020, Suceava, prize III to Ph.D. Research students section

Available online: http://fia-old.usv.ro/fiajournal/Student_in_Bucovina_2020/

2. Atudorei D., Atudorei O., Codină G.G., *Physico-chemical and consumer acceptance of white bread as affected by germinated bean flour addition*, 87 International scientific conference of young scientist and students "Youth scientific achievements to the 21st century nutrition problem solution", 15–16 April, 2021

Available online: http://conferencenuft.ho.ua/Books%20of%20abstracts/2021/Part%201.pdf

3. Atudorei D., *Improving the quality of bakery products by using germinated legume flour*, RO.aliment SHOW, fifth edition, 17-21 may, oral presentation on 20 may during Backery products & Swets & Alternative products section (invited representatives of the food industry, academia, consumers)

Available on-line: https://www.roaliment.ro/academy/event/ro-aliment-show-2021-fost-ingredients-show/

4. Atudorei D., Atudorei O., Codină G.G. *The effect of germinated beans on wheat dough rheology*, The 16th International Conference of Constructive Design and Technological Optimization in Machine Building Field OPROTEH 2021, 25-27 May, Bacău, Romania

Available online: http://oproteh.ub.ro/

5. Iuga-Ungureanu M., Atudorei D., Codină G.G., Mironeasa S., *Chemical characterization of wheat-germinated legumes composite flours*, XXIth International Multidisciplinary Scientific GeoConference Surveying, Geology and Mining, Ecology and Management – SGEM 2021

Available on-line: https://www.sgem.org/

6. Atudorei D., Codină G.G., *Dough rheological properties as affected by addition of germinated chickpea flour*, 8th Edition of the International Conference, 5th November 2021 BIOTECHNOLOGIES, PRESENT AND PERSPECTIVES

Available on-line: https://fiajournal.usv.ro/conference2021/

7. Atudorei D., Codină G.G., *The effect of germinated lentil flour on bread making*, 8th Edition of the International Conference, 5th November 2021 BIOTECHNOLOGIES, PRESENT AND PERSPECTIVES

Available on-line: https://fiajournal.usv.ro/conference2021/

8. Atudorei O., Atudorei D., *The effect of the addition of germinated soybean flour on the rheological properties of wheat flour dough*, Annual student scientific communication session, november 2021, Facultatea de Ingineria Mediului și Știința Alimentelor, Târgoviște

9. Codină G.G., Atudorei D., Ungureanu-Iuga M., Ursachi F., Amino acids composition of wheat-germinated legumes composite flours, The International conference agriculture for life, life for agriculture, June 2-4, 2022, Bucharest, Romania

O2. Production and physico-chemichal characteristics of germinated legumes flours (activity A2.3).

In order to establish the production of germinated legumes flours were determined the physical and physiological changes of different types of legumes during every day of germination process (from day 1 to 9 for soybeans, beans and chickpeas respectively to 10 days of germination process for lupine and lentils) in accordance with the conditions provided by the ISTA (2006) standard. Were measured every day the size of the radicle and plumule of legumes seeds by using a Modelcraft Vernier Calliper of 125 mm and was captured the physical and physiological changes that occur in legumes seeds during the germination process by using a Motic SMZ-140 Stereomicroscope device. All the data and images obtained may be seen in the below article:

Atudorei D, Stroe S.G., Codină G.G., 2020, *Physical, physiological and minerals changes of different legumes types during the germination process*, Ukranian Food Journal, 9 (4), 844-863, Web of Science, accession number: WOS: 000616627300008

Available online:http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202020%20V.9%20Is.4.pdf

According to the physical and physiological changes of legumes during germination it was etsablished to stop the germination process after 4 days in oder to obtained the flour from germinated legumes to be used in bread making. The physico-chemical characterization of legume seeds during the germination period (0, 2 and 4 days of germination), microstructure of legumes during germination using scanning electron microscope (SEM), appearence of legumes seeds druing germination, FT-IR analysis, relationships between physico-chemical values of legume seeds during the germination period data may be seen in the below article:

Atudorei D, Stroe S.G., Codină G.G., 2021, Impact of germination on the microstructural and physicochemical properties of different legume types, Plants-Basel, impact factor 4.658, category Q1, accession number: WOS: 000634093800001

Available online: https://www.mdpi.com/2223-7747/10/3/592

According to the data obtained the fallowing procedure were established for production of germinated legumes flours in oder to be used in bread making: The legumes were germinated, lyophilized and milled before they were used in the wheat flour. The germination was made in dark conditions at a temperature of 25°C and a constant humidity of 80%. The germination layer used was the filter paper. After 4 days of germination, the legumes seeds were freeze-dried in a lyophilizer (Biobase, BK-FD12, (Jinan, China), taking into account the following parameters: temperature −50°C, 24 h and a pressure of 10 Pa. After lyophilization, the legumes seeds were milled in a laboratory mill 3100 (Perten Instruments, Hägersten, Sweden) in order to be added into wheat flour.

Also, 3 different production process of germinated legumes flours were tested (in 1 of them the germination period of legumes were of 5 days) and described in an extenso way in patents applications filed submitted for evaluation to OSIM:

1. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., *Functional flour from germinated legumes for baking and process for obtaining it* A/00570/2021 has been title changed according to OSIM recommendations to *Process for obtaining a functional flour for bread-making obtained from germinated legumes*

2. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., *Functional white bread with an increased protein value by adding germinated legumes and the process of obtaining it*, A/00569

3. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., *Nutritionally enriched white bread with the addition of flour from germinated legumes with high enzymatic activity and process for obtaining it*, A/00568/2021 has been title changed according to OSIM recommendations to *Process for obtaining a bread-type food product nutritionally enriched with germinated legumes flour addition and the process for obtaining flour from the mix of germinated legumes*

In **conclusion**, ***all the results established to the objective O2 and activitiy A2.3 have been achieved and published. More, 3 patents applications are under evaluation to OSIM***. The data related to the **O2 objective (*activity A2.3*)** have been published in the fallowing papers, presented to the fallowing conferences and submitted to the fallowing patent application for evaluation to OSIM:

I. Articles published in journals indexed/quoted ISI

1. Atudorei D, Stroe S.G., Codină G.G., 2020, *Physical, physiological and minerals changes of different legumes types during the germination process*, Ukranian Food Journal, 9 (4), 844-863, Web of Science, accession number: WOS: 000616627300008

Available online: http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202020%20V.9%20Is.4.pdf

2. Atudorei D, Stroe S.G., Codină G.G., 2021, *Impact of germination on the microstructural and physicochemical properties of different legume types*, Plants-Basel, impact factor 4.658, ***category Q1***, accession number: WOS: 000634093800001

Available online: https://www.mdpi.com/2223-7747/10/3/592

II. Patents applications filed submitted for evaluation to OSIM

1. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., *Functional flour from germinated legumes for baking and process for obtaining it* A/00570/2021 has been title changed according to OSIM recommendations to *Process for obtaining a functional flour for bread-making obtained from germinated legumes*

2. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., *Functional white bread with an increased protein value by adding germinated legumes and the process of obtaining it*, A/00569

3. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., *Nutritionally enriched white bread with the addition of flour from germinated legumes with high enzymatic activity and process for obtaining it*, A/00568/2021 has been title changed according to OSIM recommendations to *Process for obtaining a bread-type food product nutritionally enriched with germinated legumes flour addition and the process for obtaining flour from the mix of germinated legumes*

III. Conference participations

1. Atudorei D., Golea C., *Physical and physiological modifications of different legumes types during the germination process*, oral presentation to the 9th Edition for International Conference for Students-Student in Bucovina, 18 December 2020, Suceava, prize III to Ph.D. Research students section

Available online: http://fia-old.usv.ro/fiajournal/Student_in_Bucovina_2020/

2. Atudorei D., *Improving the quality of bakery products by using germinated legume flour*, RO.aliment SHOW, fifth edition, 17-21 may, oral presentation on 20 may during Backery products & Swets & Alternative products section (invited representatives of the food industry, academia, consumers)

Available on-line: https://www.roaliment.ro/academy/event/ro-aliment-show-2021-fost-ingredients-show/

O3. Physico-chemical characteristics of composite flours (**activity 2.6**).

All the data obatined regarding the physico-chemical characterization of the composite flours obtained (mix of wheat flour and one type of germinated flours from lentil, chickpea, soybean, lupin,

bean) such as humidity, ash, acidity, proteins, lipids and mineral content have been presented and discussed in a large extense in the article below:

Codină G.G., Iuga M., Stroe S.G., Mironeasa S., Chemical characterization of wheat-germinated legumes composite flours, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, Volume 21, Issue 6.1, Pages 79 – 87, DOI: 10.5593/sgem2021/6.1/s25.11 – SCOPUS indexed

All the data were determined for the mixes formed from wheat flour and it subtitution level of 2.5, 5, 7.5, 10, 15, 20, 25% germinated legumes flours from lentil, chickpea, soybean, lupin and bean.

All the results established to the objective O3 and activitiy A2.6 have been achieved and published or accepted for publication (the article in extenso are loaded in the UEFSICDI system) where the results obtained are discussed in a very extensive way. The only data that are not published but are accepted for publication are related to the the amino acids content of the composite flours. The amino acids content data will be published in the article bellow:

Ursachi F., Atudorei D., Ungureanu-Iuga M., Codină G.G., Amino acids composition of wheat-germinated legumes composite flours, accepted for publication in Scientific Bulletin. Series F. "Biotechnologies", ISSN 2285-1364, International Database Indexing: Index Copernicus, CABI, DOAJ, Ulrich's Periodicals Directory (ProQuest), PBN, Cite Factor (Academic Scientific Journals), Scipio, OCLC (WorldCat), Research Bible, Google Scholar.

Regarding the esential amino-acids content of the composite flour for the wheat-germinated bean mix the highest amount were obtained for histidine, fallowed by valine, isoleucine, threonine, phenylalanine, leucine of which value increased with the increse level of germinated bean flour addition in wheat flour. Also for the mixes formed from germinated lentil-wheat flour, germinated soybean-wheat flour, germinated lupine-wheat flour the highest amounts were recorded for the histidine fallowed by valine whereas for the mix between germinated chickpea-wheat flour the highest amounts were recorded for valine fallowed by histidine. These values increased with the increase level of germinated legume type flour addition. Regarding the amount of non-essential amino acids content the highest levels were obatined for glutamic acid for all the mixes between germinated legumes and wheat flour and the lowest one for glycine.

In conclusion, the data related to the **O3 objective** (**activity 2.6**) have been presented in the fallowing papers:

1. Codină G.G., Iuga M., Stroe S.G., Mironeasa S., Chemical characterization of wheat-germinated legumes composite flours, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, Volume 21, Issue 6.1, Pages 79 – 87, DOI: 10.5593/sgem2021/6.1/s25.11 – SCOPUS indexed
2. Ursachi F., Atudorei D., Ungureanu-Iuga M., Codină G.G., Amino acids composition of wheat-germinated legumes composite flours, accepted for publication in Scientific Bulletin. Series F. "Biotechnologies", ISSN 2285-1364, International Database Indexing: Index Copernicus, CABI, DOAJ, Ulrich's Periodicals Directory (ProQuest), PBN, Cite Factor (Academic Scientific Journals), Scipio, OCLC (WorldCat), Research Bible, Google Scholar.

O4. Evaluation of rheological properties of composite flours (***activities A2.7, A2.8, A2.9, A3.1***).

In order to establish to what level we must substitute the wheat flour with a germinated legume one the falling number of the different mixes flours were determined. According to the data obtained we etsablihed a substitution level up to 10% for germinated lentil flour, up to 20% for germinated lupine, chickpea, soy bean and up to 25% for germinated bean flour. With the increase level of germinated legumes addition the falling number decreased. Our propose was to achieve a falling number which to corrsespond to the optimum one namely 220-290 s which was the normal amylase activity. One of the propose of the project was to decrease the falling number value of the wheat flour which was of a low amylase activity (values higher than 300 s), in our case 350 s to a normal amylase activity. The falling number decreased with germinated bean flour substitution (25%) up to 262 s, with lentil germinated flour (10%) up to 229 s, with soy germinated flour (20%) up to 243 s, with germinated lupin up to 247 s and with germinated chickpea up to 261 s. Therefore the mix flours with the maximum level of germinated flour addition varying function of type were optimum for the falling number point of view (amylase in especially the alpha amylase one).

The empirical dough rheological properties data during mixing (activity A2.7), extension (activity A2.8), fermentation (activity A2.9) and fundamental one (activity A3.1) of composite flours may be seen in the articles below (***mix of wheat flour and single germinated flour from lentil – article 4 and 5, chickpea – article 3, soybean – article 5, lupine –article 2, bean –article 1 or different combinations addition between germinated flours –articles 5 and 6***):

1. Atudorei D, Atudorei O, Codină G.G., 2021, *Dough rheological properties, microstructure and bread quality of wheat-germinated bean composite flour*, Foods, impact factor 5.561, ***category Q1***, accession number: WOS: 000676853800001

Available online: https://www.mdpi.com/2304-8158/10/7/1542

2. Atudorei D., Ropciuc S., Codină G.G., Possibilities to use germinated lupine flour as an ingredient in breadmaking to improve the final product quality, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000775367400001

Available online: https://www.mdpi.com/2073-4395/12/3/667

3. Atudorei D., Atudorei O., Codină G.G., The impact of germinated chickpea flour addition on dough rheology and bread quality, Plants-Basel, impact factor 4.658, **Q1 journal**, accession number: WOS: 000794770500001

Available online: https://www.mdpi.com/2223-7747/11/9/1225

4. Atudorei D., Mironeasa S., Codină G.G., Effects of germinated lentil flour on dough rheological behavior and bread quality, Foods, impact factor 5.561, **Q1 journal**

Available online: https://www.mdpi.com/2304-8158/11/19/2982

5. Ungureanu-Iuga M., Atudorei D., Codină G.G., Mironeasa S., 2021, Rheological approaches of wheat flour dough enriched with germinated soybean and lentil, Applied Sciences, impact factor 2.838, **Q2 journal,** accession number: WOS: 000742694600001

Available online: https://www.mdpi.com/2076-3417/11/24/11706

6. Atudorei D., Ungureanu-Iuga M., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000735685200001

Available online: https://www.mdpi.com/2073-4395/11/12/2588

In the ***article no. 1*** the effect of germinated bean flour (GBF) levels (0, 5, 10, 15, 20, 25%) addition in wheat flour on empirical dough rheological properties (mixing extension, fermentation), fundamental ones and also falling number may be seen. All the results obatined are discussed in an extension way. Summary, the presence of active enzyme, dietary fiber and non-gluten proteins from GBF were responsible for the decrease of the dough consistency, baking strength and extensibility mainly due to the gluten network modifications. During fermentation, the maximum height of gaseous production and total CO_2 volume production were improved up to a certain level of GBF addition due also to an increase of the α-amylase activity. However, at high levels of GBF addition, these values decreased, probably due to the gluten dilution from the dough system. The effect of GBF addition in wheat flour on dynamic dough rheological properties shown that tan δ increased in a frequency-dependent manner. G' and G'' increased with high levels of GBF addition in wheat flour, indicating that an addition GBF improved the dough viscoelasticity. The tan δ lower than 1 for all dough samples showed a solid-like behavior of the dough samples

In the ***articles no 2 and 3***, the effect of germinated lupine flour (GLF) and germinated chickpea flour (GCF) on dough rheological properties have been presented. According to the data obtained, GCF addition in wheat flour resulted in a significant decrease ($p < 0.05$) of Falling Number values (up to 261 s) as the level was higher and compared to the control, a similar trend being observed for GLF (up to 247 s) incorporation. Dough mixing behavior in terms of water absorption, and dough conistency parameters showed significant reduction as the amount of GCF raised, while dough tolerance to kneading varied irregularly. Similar reduction trends of water absorption and dough consistency values were observed for GLF samples, while dough tolerance to kneading parameter decreased proportionally. Significant decreases ($p < 0.05$) of dough extensibility and baking strength were obtained as the levels of GCF or GLF were higher and compared to the control. Dough tenacity increased as the amount of GLF raised, while GCF determined an irregularly variation. The Alveograph curve configuration ratio values also increased proportional with GCF or GLF addition level. All the parameters listed above were influenced significantly ($p < 0.05$) by GCF or GLF incorporation. On dough empirical rheological properties during fermentation, the maximum

height of gaseous production, total CO_2 volume production increased up to 10% GCF or GLF addition after which this value decreased. In general the volume of the gas retained in the dough at the end of the test was decreased at high levels of GLF and GCF addition while the retention coefficient varies irregularly. The storage modulus, the loss modulus and the loss tangent, are largely determined by frequency for dough samples. The ratio of viscous and elastic components was less than 1, regardless of the level of GCF and GLF addition to wheat flour. Generally, all the dough samples with GCF and GLF addition to the wheat flour presented lower values for *G'* and *G"*and higher ones for tan δ compared with the control sample.

In the ***article no 4*** dough fundamental rheological properties are presented (the empirical ones being presented in article 5). According to the data obtained, the creep compliance values decreased with an increased addition of LGF. Only at an addition of 10% LGF in the wheat flour did the value of these parameters significantly increase ($p < 0.05$), but without exceeding the values for the control sample.

In the ***article no. 5*** the effect of germinated lentil flour levels (0, 2.5, 5, 7.5, 10%), germinated soybean flour (0, 5, 10, 15, 20%) addition in wheat flour on empirical dough rheological properties (mixing, extension, fermentation and also falling number may be seen) and fundamental ones. All the results obatined are discussed in an extension way. Summary, germinated lentil flour led to the decrease of falling number, water absorption, kneading tolerance, dough extensibility, and baking strength, while dough consistency, configuration ratio of the Alveograph curve increased proportionally with the amount used. Soybean germinated flour addition level increase induced lower values of falling number, water absorption, dough extensibility, baking strength, the maximum height of gaseous production, the volume of gas retained in the dough at the end of the test, while the configuration ratio of the Alveograph curve raised with the level increase. Both dynamic modules increased with the increased level of LGF and SGF.

More, the combination between germinated lentil flour (LGF) and germinated soybean flour (SGF) on dough rheological properties (including mixing, extension, fermentation and falling number values) have been analyzed and discussed. The interactions between SGF and LGF exerted significant ($p < 0.05$) influences on the falling number, dough consistency after 450 s and dough baking strength. The optimization was performed on a trial version of Design Expert software (Stat-Ease, Inc., Minneapolis, USA). A full factorial design with two factors varied at five levels, SGF addition at 0, 5, 10, 15, and 20% and LGF addition at 0, 2.5, 5, 7.5, and 10%, and Response Surface Methodology (RSM) with a two-factor interaction (2FI) model were used. The effects of SGF and LGF addition levels on dough properties were evaluated through mathematical modeling. The most suitable model to predict data variation for each response was selected according to *F*-test results, coefficient of determination (R^2), and adjusted coefficients of determination ($Adj.\text{-}R^2$). The effects of factors and their interactions were underlined using Analysis of Variance (ANOVA), considering a significance level of 95%.

The optimal addition levels of SGF and LGF in wheat flour conducted to the predicted values of the responses for the empirical dough rheological during mixing, extension and fermentation: water absorption 53.25%, tolerance to kneading 200.19s, dough consistency after 250 s 359.8 mb, dough consistency after 450 s 933.32 s, dough tenacity 119.95 mm, dough extensibility 56.20 mm, baking strength 228.64 10^{-4} J , Alveograph curve configuration ratio 1.99, maximum height of gaseous production 70.50 mL, total CO_2 volume production 1684.98 mL, the volume of the gas retained in the dough at the end of the test 1305.19 mL, retention coefficient 78.78%, the dynamic modules *G'* 41.384 Pa and *G"* 16.296 Pa. The results of the optimization of the considered response revealed that the optimal formulation contains 5.60% SGF, 3.62% LGF, and 90.76% wheat flour. The Falling Number (280.51s) and the empirical rheological properties of the optimal sample showed significantly different ($p < 0.05$) values compared to the control sample.

In the ***article no. 6*** the combined effect of germinated lupin flour (LGF) and germinated chickpea flour (CGF) have been analyzed and discussed. For this purpose, the Response Surface Methodology (RSM) and a full factorial design with two factors (CGF and LGF amounts), both varied at 0, 5, 10, 15, and 20% have been used. The best predictive model for the experimental data variation for each response was chosen by taking into account F-test values, coefficient of determination (R^2), and adjusted coefficients of determination ($Adj.\text{-}R^2$). Analysis of Variance (ANOVA) was applied in order to evaluate the influence of factors and their interactions (significant at $p < 0.05$) on the dough

rheological properties (including the empirical ones on mixing, extension, fermentation and also Falling Number values). The optimization of factors was done by applying the desirability function. For this purpose, the factors (CGF and LGF) were kept in range, the Falling number parameter was minimized, the rheological parameters during fermentation were maximized, while the rheological characteristics during mixing and extension were kept in range. The experimental design and the optimization were done on the trial version of Design Expert software (Stat-Ease, Inc., Minneapolis, USA). *Student-t-test* was employed to evaluate the differences considered significant at $p < 0.05$ between the optimal and control sample, by using XLSTAT for Excel 2021 version (Addinsoft, New York, USA) software.

The optimal formulation from a rheological point of view was obtained by incorporating 8.57% CGF and 5.31% LGF in wheat flour. The objective of this study - to decrease the Falling Number, was achieved significantly lower value ($p < 0.05$) was obtained for the optimal sample (282.6 s) compared to the control (350 s). The optimal addition levels of CGF and LGF in wheat flour conducted to the predicted values of the responses for the empirical dough rheological during mixing, extension and fermentation: water absorption 52.91%, tolerance to kneading 191.49s, dough consistency after 250 s 238.55 mb, dough consistency after 450 s 806.45 s, dough tenacity 124.55 mm, dough extensibility 36.15 mm, baking strength 183.65 10^{-4} J, Alveograph curve configuration ratio 3.78, maximum height of gaseous production 66.80 mL, total CO_2 volume production 1579.31 mL, the volume of the gas retained in the dough at the end of the test 1204.14 mL, retention coefficient 81.97%, *G'* 41.538 Pa and *G"* 15.446 Pa.

The optimal sample presented lower water absorption, tolerance to kneading, dough consistency, extensibility, the volume of the gas retained in the dough at the end of the test, compared to the control. The values for dough tenacity, curve configuration ratio, the maximum height of gaseous production, total CO_2 volume production, gas retention coefficient, visco-elastic moduli, maximum gelatinization temperature were higher for the optimal sample compared to the control.

All the results established to the objective O4 and activities A2.7, A2.8, A2.9, A3.1 have been achieved and published. The results obtained are discussed in a very extensive way (the singular effect of all germinated legumes flours and the combined effect between germinated lentil flour and germinated soybean flour and the combined effect between germinated chickpea flour and germinated lupin flour on dough rheological properties and also falling number value) in the published articles.

In **conclusion**, the data related to the **O4 objective (*activities A2.7, A2.8, A2.9, A3.1*)** have been published in the fallowing papers and presented to the fallowing conferences:

I. Articles published in journals indexed ISI

1. Atudorei D, Atudorei O, Codină G.G., 2021, *Dough rheological properties, microstructure and bread quality of wheat-germinated bean composite flour*, Foods, impact factor 5.561, ***category Q1***, accession number: WOS: 000676853800001

Available online: https://www.mdpi.com/2304-8158/10/7/1542

2. Atudorei D., Ropciuc S., Codină G.G., Possibilities to use germinated lupine flour as an ingredient in breadmaking to improve the final product quality, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000775367400001

Available online: https://www.mdpi.com/2073-4395/12/3/667

3. Atudorei D., Atudorei O., Codină G.G., The impact of germinated chickpea flour addition on dough rheology and bread quality, Plants-Basel, impact factor 4.658, **Q1 journal**, accession number: WOS: 000794770500001

Available online: https://www.mdpi.com/2223-7747/11/9/1225

4. Atudorei D., Mironeasa S., Codină G.G., Effects of germinated lentil flour on dough rheological behavior and bread quality, Foods, impact factor 5.561, **Q1 journal**

Available online: https://www.mdpi.com/2304-8158/11/19/2982

5. Ungureanu-Iuga M., Atudorei D., Codină G.G., Mironeasa S., 2021, Rheological approaches of wheat flour dough enriched with germinated soybean and lentil, Applied Sciences, impact factor 2.838, **Q2 journal,** accession number: WOS: 000742694600001

Available online: https://www.mdpi.com/2076-3417/11/24/11706

6. Atudorei D., Ungureanu-Iuga M., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000735685200001

II. Conference participations

1. Atudorei D., *Improving the quality of bakery products by using germinated legume flour*, RO.aliment SHOW, fifth edition, 17-21 may, oral presentation on 20 may during Backery products & Swets & Alternative products section (invited representatives of the food industry, academia, consumers)

Available on-line: https://www.roaliment.ro/academy/event/ro-aliment-show-2021-fost-ingredients-show/

2. Atudorei D., Atudorei O., Codină G.G. *The effect of germinated beans on wheat dough rheology*, The 16th International Conference of Constructive Design and Technological Optimization in Machine Building Field OPROTEH 2021, 25-27 May, Bacău, Romania

Available online: http://oproteh.ub.ro/

3. Atudorei D., Codină G.G., *Dough rheological properties as affected by addition of germinated chickpea flour*, 8th Edition of the International Conference, 5th November 2021 BIOTECHNOLOGIES, PRESENT AND PERSPECTIVES

Available on-line: https://fiajournal.usv.ro/conference2021/

4. Atudorei D., Codină G.G., *The effect of germinated lentil flour on bread making*, 8th Edition of the International Conference, 5th November 2021 BIOTECHNOLOGIES, PRESENT AND PERSPECTIVES

Available on-line: https://fiajournal.usv.ro/conference2021/

5. Atudorei O., Atudorei D., *The effect of the addition of germinated soybean flour on the rheological properties of wheat flour dough*, Annual student scientific communication session, november 2021, Facultatea de Ingineria Mediului și Știința Alimentelor, Târgoviște

O5. Microstructure analysis of dough from composite flours (activity A3.2)

All the data obatined regarding the microstructure analysis of the composite flours obtained (mix of wheat flour and one type of germinated flours from lentil, chickpea, soybean, lupin, bean in a single or different combinations) have been presented and discussed in a large extense in the articles below as fallowing:

The effect of germinated bean addition in wheat flour on dough microstructure:

Atudorei D, Atudorei O, Codină G.G., 2021, Dough rheological properties, microstructure and bread quality of wheat-germinated bean composite flour, Foods, impact factor 5.561, ***Q1 journal***, accession number: WOS: 000676853800001

Available online: https://www.mdpi.com/2304-8158/10/7/1542

The effect of germinated lupine addition in wheat flour on dough microstructure:

Atudorei D., Ropciuc S., Codină G.G., Possibilities to use germinated lupine flour as an ingredient in breadmaking to improve the final product quality, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000775367400001

Available online: https://www.mdpi.com/2073-4395/12/3/667

The effect of germinated chickpea flour addition in wheat flour on dough microstructure:

Atudorei D., Atudorei O., Codină G.G., The impact of germinated chickpea flour addition on dough rheology and bread quality, Plants-Basel, impact factor 4.658, **Q1 journal**, accession number: WOS: 000794770500001

Available online: https://www.mdpi.com/2223-7747/11/9/1225

The effect of germinated lentil flour addition in wheat flour on dough microstructure:

Atudorei D., Mironeasa S., Codină G.G., Effects of germinated lentil flour on dough rheological behavior and bread quality, Foods, impact factor 5.561, **Q1 journal**

Available online: https://www.mdpi.com/2304-8158/11/19/2982

The data releated on SGF addition in wheat flour on dough microstructure will be soon submitted for evaluation for publication. According to our data obtained, the dough samples with different levels of SGF addition shows significant difference among the samples. The spatial distribution of protein and starch within the dough structure is changing with the increase level of

SGF addition which led to a higher red area and a less green one, indicating a more protein content and a lower starch one in the dough network.

The effect of the mix between germinated lentil flour and germinated soybean flour addition in wheat flour on dough microstructure:

Ungureanu-Iuga M., Atudorei D., Codină G.G., Mironeasa S., 2021, Rheological approaches of wheat flour dough enriched with germinated soybean and lentil, Applied Sciences, impact factor 2.838, **Q2 journal,** accession number: WOS: 000742694600001

Available online: https://www.mdpi.com/2076-3417/11/24/11706

The effect of the mix between germinated chickpea flour and germinated lupine flour addition in wheat flour on dough microstructure:

Atudorei D., Ungureanu-Iuga M., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000735685200001

Available online: https://www.mdpi.com/2073-4395/11/12/2588

In **conclusion**, except the effect of the single germinated soybean flour (SGF) addition on wheat flour (which wants to be published) all the data related to the **O5 objective (*activity A3.2*)** have been published in **6 ISI journals in Q1 and Q2 category.**

O6. Evaluation of the bread products quality obtained from composite flours (activities A3.3, A3.4, A3.5, A3.6, A3.7, A3.8, A3.9).

All the data obatined regarding the bread-making process and bread quality (physical, microstructural, sensorial, textural, color – activity A3.3, A3.4, A3.5, A3.6, A3.7, A3.8) from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean) have been presented and discussed in a large extense in the articles below as fallowing:

The effect of germinated bean addition in wheat flour on bread quality:

Atudorei D, Atudorei O, Codină G.G., 2021, Dough rheological properties, microstructure and bread quality of wheat-germinated bean composite flour, Foods, impact factor 5.561, ***Q1 journal***, accession number: WOS: 000676853800001

Available online: https://www.mdpi.com/2304-8158/10/7/1542

The effect of germinated lupine addition in wheat flour on bread quality:

Atudorei D., Ropciuc S., Codină G.G., Possibilities to use germinated lupine flour as an ingredient in breadmaking to improve the final product quality, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000775367400001

Available online: https://www.mdpi.com/2073-4395/12/3/667

The effect of germinated chickpea flour addition in wheat flour on bread quality:

Atudorei D., Atudorei O., Codină G.G., The impact of germinated chickpea flour addition on dough rheology and bread quality, Plants-Basel, impact factor 4.658, **Q1 journal**, accession number: WOS: 000794770500001

Available online: https://www.mdpi.com/2223-7747/11/9/1225

The effect of germinated lentil flour addition in wheat flour on bread quality

Atudorei D., Mironeasa S., Codină G.G., Effects of germinated lentil flour on dough rheological behavior and bread quality, Foods, impact factor 5.561, **Q1 journal**

Available online: https://www.mdpi.com/2304-8158/11/19/2982

The data releated on SGF addition in wheat flour on bread quality will be soon submitted for evaluation in order to be published. According to our data obtained, the bread quality were improved up to a 15% SGF addition level in wheat flour. Regarding the color parameters values, our data shown a decrease of L* and an increase of the a* and b* values for the bread crumbs and crust, indicating a darkening of their color. The crumb microstructure of the bread samples showed larger pore sizes at high levels of SGF probably due to the SGF dilution effect on the gluten matrix. From a sensory point of view, the bread sample characteristics were well-appreciated up to a 15% SGF addition level in wheat flour. The bread textural characteristics presented significant changes by SGF addition in wheat flour. The firmeness value increased whereas the gumminess, cohesiveness and resilience presented some fluctuations.

The nutritional quality of bread obtained from composite flours (activity A3.9) had been presented in 1 published article (Q1 journal), 2 patents and 3 papers presented to different conferences as fallowing:

I. Articles published in journals quoted ISI (Q1 category)

1. Atudorei D, Atudorei O, Codină G.G., 2021, Dough rheological properties, microstructure and bread quality of wheat-germinated bean composite flour, Foods, impact factor 5.561, ***Q1 journal***, accession number: WOS: 000676853800001

Available online: https://www.mdpi.com/2304-8158/10/7/1542

II. Patents applications filed submitted for evaluation to OSIM

1. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., *Functional white bread with an increased protein value by adding germinated legumes and the process of obtaining it*, A/00569

2. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., *Nutritionally enriched white bread with the addition of flour from germinated legumes with high enzymatic activity and process for obtaining it*, A/00568/2021 has been title changed according to OSIM recommendations to *Process for obtaining a bread-type food product nutritionally enriched with germinated legumes flour addition and the process for obtaining flour from the mix of germinated legumes*

III. Conference participations

1. Atudorei D., *Improving the quality of bakery products by using germinated legume flour*, RO.aliment SHOW, fifth edition, 17-21 may, oral presentation on 20 may during Backery products & Swets & Alternative products section (invited representatives of the food industry, academia, consumers)

Available on-line: https://www.roaliment.ro/academy/event/ro-aliment-show-2021-fost-ingredients-show/

2. Atudorei D., Atudorei O., Codină G.G., Nutritional impact of the germinated bean flour addition in the recipe for making white wheat bread, 88 International scientific conference of young scientist and students "Youth scientific achievements to the 21st century nutrition problem solution", April-May, Kyiv, NUFT, 2022

Available on-line: http://conferencenuft.ho.ua/Books%20of%20abstracts/2022/Part%201.pdf

3. Codină G.G., Atudorei D., Ungureanu-Iuga M., Ursachi F., Stroe S.G., Effects of germinated lupine and chickpea flour addition on nutritional quality of white wheat bread, 4th World conference on sustainable life sciences, 1-7 August, Istanbul, Turkey

Available on-line: https://www.wocols.com/

4. Codină G.G., Atudorei D., Ursachi F., Stroe S.G., Ungureanu-Iuga M., Nutrition value of white wheat bread supplemented with soybean and lentil germinated flour, European Biotechnology Congress 2022, 5-7 October, Prague, Czechia

Available on-line: http://eurobiotech2022.eu/

In the published article it is presented in an extensive way the compositional analysis of bread samples with different levels of germinated bean flour addition in wheat flour. In the patent 1 are presented the nutritional value of bread obtained from a mix of germinated legumes flours from lupine, soybean and bean added in a proportion level of 20% in wheat flour whereas in the patent 2 are presented the nutritional value of bread obtained from a mix of germinated legumes flours from lentil, chickpea and bean added in a proportion level of 10% in wheat flour. To the conferences have been presented the nutritional value of bread obtained from composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin bean). According to the data obtained the protein and fat significant ($p<0.05$) increased with the increase level of germinated flour addition in wheat flour. The carbohydrates content decreased with the increased level of germinated flour addition in wheat flour whereas the moisture content of the bread presented various fluctuations. The energetic value of breads slightly increased when germinated flours were added in bread recipe. Except the carbohydrates values all the chemical compounds of the bread sample with the optimum mixes previously obtained and discussed to the rheological data namely mix from 5.60% germinated

soybean flour (SGF) and 3.62% germinated lupine flour (GLF) and mix from 8.57% germinated chickpea flour (GCF) and 5.31% germinated lupine flour (GLF) addition increased. The acidity value of all bread samples were around 3 grades with no significant differences between samples. Compared to the control sample, all the minerals elements analyzed (Ca, Cu, Fe, K, Mg, Mn, Na, Zn) increased with the increase level of SGF and GLF addition in wheat flour. For the bread samples with GCF and GLF high levels were recorded for Cu, Na and Zn. For bread sample with germinated bean flour addition a significant increased ($p<0.05$) were recorded for Mn, K and Fe. From the amino acids point of view, high levels were obtained for the essential amino acids histidine and valine and for the non-essential amino acid glutamic acid for all bread samples with germinated flours addition in bread recipe. It may be concluded that all bread supplemented with germinated flour addition in wheat flour were nutritionally improved from the chemical, minerals and amino acids point of view. More thorugh the germination process the antinutrients contents of the legumes used in bread recipe decreased fact that favor the availability of the amino acids, minerals and vitamins from the bread samples. By bread consumption with germinated flour addition in wheat flour the balance of nutrients were increased and therefore their assimilation by the human body were increased.

In **conclusion**, the nutritional quality of bread samples with germinated flour addition have been ***been achieved and published*** in 4 ISI journals in Q1 and Q2 category, in 2 patents sumbited for evaluation to OSIM and presented to 4 scientifical conferences.

Dissemination of research results. According to the Annex II of Contract No. TE158/2020 during the period November 2020-December 2021 (stage 1 and 2) should be delivered (**Activity 2.10**) the publication of at least 1 article ISI, proposed to OSIM of minimum 3 patents, participation to at least 2 conferences (1 with the industrial participation) and during the period January 2022-October 2022 (stage 3) should be delivered (**Activity 3.10**) the publication of at least 2 articles ISI, participation to at least 1 conference.

It was achieved much more that was propose by us as fallowing: in the **stage 1 and 2 of the project** 6 articles published in ISI journals from which 5 in Q1/Q2 category, 1 BDI article published (SCOPUS indexed), under ISI WEB evaluation, 3 patents applications filed submitted for evaluation to OSIM, 8 papers presented to different conferences (1 with the industrial participation - RO.aliment SHOW, fifth edition, 17-21 May, oral presentation– after the presentation Millbo company contact us for a collaboration) and in the **stage 3 of the project** 3 articles published in ISI journals (Q1 category), 1 BDI article accepted for publication, 4 papers presented to different international conferences. **Totally**, during the **entire period of the project** was published 9 articles in ISI journals (from which 6 in Q1 category and 2 in Q2 category), 1 BDI article (SCOPUS indexed), 1 BDI article accepted for publication, 3 patents applications filed submitted for evaluation to OSIM and 12 participation with presentation to different conferences as fallowing:

I. Articles published in journals indexed/quoted ISI

1. Atudorei D, Codină G.G., 2020, *Perspectives on the use of germinated legumes in the bread making process, a review*, Applied Sciences, impact factor 2.838, ***Q2 journal***, accession number: WOS:000580385400001

Available online: https://www.mdpi.com/2076-3417/10/18/6244

2. Atudorei D, Stroe S.G., Codină G.G., 2020, Physical, physiological and minerals changes of different legumes types during the germination process, Ukranian Food Journal, 9 (4), 844-863, Web of Science, accession number: WOS: 000616627300008

Available online: http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202020%20V.9%20Is.4.pdf

3. Atudorei D, Stroe S.G., Codină G.G., 2021, Impact of germination on the microstructural and physicochemical properties of different legume types, Plants-Basel, impact factor 4.658, ***Q1 journal***, accession number: WOS: 000634093800001

Available online: https://www.mdpi.com/2223-7747/10/3/592

4. Atudorei D, Atudorei O, Codină G.G., 2021, Dough rheological properties, microstructure and bread quality of wheat-germinated bean composite flour, Foods, impact factor 5.561, ***Q1 journal***, accession number: WOS: 000676853800001

Available online: https://www.mdpi.com/2304-8158/10/7/1542

5. Ungureanu-Iuga M., Atudorei D., Codină G.G., Mironeasa S., 2021, Rheological approaches of wheat flour dough enriched with germinated soybean and lentil, Applied Sciences, impact factor 2.838, **Q2 journal,** accession number: WOS: 000742694600001

Available online: https://www.mdpi.com/2076-3417/11/24/11706

6. Atudorei D., Ungureanu-Iuga M., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000735685200001

Available online: https://www.mdpi.com/2073-4395/11/12/2588

7. Atudorei D., Ropciuc S., Codină G.G., Possibilities to use germinated lupine flour as an ingredient in breadmaking to improve the final product quality, Agronomy-Basel, impact factor 3.949, **Q1 journal**, accession number: WOS: 000775367400001

Available online: https://www.mdpi.com/2073-4395/12/3/667

8. Atudorei D., Atudorei O., Codină G.G., The impact of germinated chickpea flour addition on dough rheology and bread quality, Plants-Basel, impact factor 4.658, **Q1 journal**, accession number: WOS: 000794770500001

Available online: https://www.mdpi.com/2223-7747/11/9/1225

9. Atudorei D., Mironeasa S., Codină G.G., Effects of germinated lentil flour on dough rheological behavior and bread quality, Foods, impact factor 5.561, **Q1 journal**

Available online: https://www.mdpi.com/2304-8158/11/19/2982

II. Articles published in journals indexed BDI

1. Codină G.G., Iuga M., Stroe S.G., Mironeasa S., Chemical characterization of wheat-germinated legumes composite flours, International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, Volume 21, Issue 6.1, Pages 79 – 87, DOI: 10.5593/sgem2021/6.1/s25.11 – SCOPUS indexed

2. Ursachi F., Atudorei D., Ungureanu-Iuga M., Codină G.G., Amino acids composition of wheat-germinated legumes composite flours, accepted for publication in Scientific Bulletin. Series F. "Biotechnologies", ISSN 2285-1364, International Database Indexing: Index Copernicus, CABI, DOAJ, Ulrich's Periodicals Directory (ProQuest), PBN, Cite Factor (Academic Scientific Journals), Scipio, OCLC (WorldCat), Research Bible, Google Scholar.

III. Patents applications filed submitted for evaluation to OSIM

1. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., Functional flour from germinated legumes for baking and process for obtaining it A/00570/2021 has been title changed according to OSIM recommendations to ***Process for obtaining a functional flour for bread-making obtained from germinated legumes***

2. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., ***Functional white bread with an increased protein value by adding germinated legumes and the process of obtaining it***, A/00569

3. Codină G.G., Mironeasa S., Atudorei D., Mușu A., Ungureanu-Iuga M., Oroian M.A., Nutritionally enriched white bread with the addition of flour from germinated legumes with high enzymatic activity and process for obtaining it, A/00568/2021 has been title changed according to OSIM recommendations to ***Process for obtaining a bread-type food product nutritionally enriched with germinated legumes flour addition and the process for obtaining flour from the mix of germinated legumes***

IV. Conference participations

1. Atudorei D., Golea C., Physical and physiological modifications of different legumes types during the germination process, oral presentation to the 9th Edition for International Conference for Students-Student in Bucovina, 18 December 2020, Suceava, prize III to Ph.D. Research students section

Available online: http://fia-old.usv.ro/fiajournal/Student_in_Bucovina_2020/

2. Atudorei D., Atudorei O., Codină G.G., Physico-chemical and consumer acceptance of white bread as affected by germinated bean flour addition, 87 International scientific conference of

young scientist and students “Youth scientific achievements to the 21st century nutrition problem solution”, 15–16 April, 2021

Available online: http://conferencenuft.ho.ua/Books%20of%20abstracts/2021/Part%201.pdf

3. Atudorei D., Improving the quality of bakery products by using germinated legume flour, RO.aliment SHOW, fifth edition, 17-21 may, oral presentation on 20 may during Backery products & Swets & Alternative products section (invited representatives of the food industry, academia, consumers)

Available on-line: https://www.roaliment.ro/academy/event/ro-aliment-show-2021-fost-ingredients-show/

4. Atudorei D., Atudorei O., Codină G.G. The effect of germinated beans on wheat dough rheology, The 16th International Conference of Constructive Design and Technological Optimization in Machine Building Field OPROTEH 2021, 25-27 May, Bacău, Romania

Available online: http://oproteh.ub.ro/

5. Iuga-Ungureanu M., Atudorei D., Codină G.G., Mironeasa S., Chemical characterization of wheat-germinated legumes composite flours, XXIth International Multidisciplinary Scientific GeoConference Surveying, Geology and Mining, Ecology and Management – SGEM 2021

Available on-line: https://www.sgem.org/

6. Atudorei D., Codină G.G., Dough rheological properties as affected by addition of germinated chickpea flour, 8th Edition of the International Conference, 5th November 2021 Biotechnologies, present and Perspectives

Available on-line: https://fiajournal.usv.ro/conference2021/

7. Atudorei D., Codină G.G., The effect of germinated lentil flour on bread making, 8th Edition of the International Conference, 5th November 2021 Biotechnologies, present and perspectives

Available on-line: https://fiajournal.usv.ro/conference2021/

8. Atudorei O., Atudorei D., The effect of the addition of germinated soybean flour on the rheological properties of wheat flour dough, Annual student scientific communication session, november 2021, Facultatea de Ingineria Mediului și Știința Alimentelor, Târgoviște

9. Atudorei D., Atudorei O., Codină G.G., Nutritional impact of the germinated bean flour addition in the recipe for making white wheat bread, 88 International scientific conference of young scientist and students “Youth scientific achievements to the 21st century nutrition problem solution”, April-May, Kyiv, NUFT, 2022

Available on-line: http://conferencenuft.ho.ua/Books%20of%20abstracts/2022/Part%201.pdf

10. Codină G.G., Atudorei D., Ungureanu-Iuga M., Ursachi F., Amino acids composition of wheat-germinated legumes composite flours, The International conference agriculture for life, life for agriculture, June 2-4, 2022, Bucharest, Romania

11. Codină G.G., Atudorei D., Ungureanu-Iuga M., Ursachi F., Stroe S.G., Effects of germinated lupine and chickpea flour addition on nutritional quality of white wheat bread, 4th World conference on sustainable life sciences, 1-7 August, Istanbul, Turkey

Available on-line: https://www.wocols.com/

12. Codină G.G., Atudorei D., Ursachi F., Stroe S.G., Ungureanu-Iuga M., Nutrition value of white wheat bread supplemented with soybean and lentil germinated flour, European Biotechnology Congress 2022, 5-7 October, Prague, Czechia

Available on-line: http://eurobiotech2022.eu/

Conclusions

All the research objectives proposed in the Annex II of Contract No. TE158/2020 was completed and was achieved. More, in addition to what was etsablished in the project activities form more data were obatined such as scanning electron microscope (SEM) images for legumes and germinated legumes microstructure, Fourier transform infrared spectroscopic (FT-IR) spectra of legumes during germination, Stereo Microscope images for legumes during germination process, e.g. According to the data obtained, all the germination flours obtained though lyophilisation may be succesufuly used as bread making natural improvers that may replace chemical additives in order to obtain a bread of a good quality from the nutritional and technological point of view. The highest

level of germinated flour that must be added in a wheat flour of a strong quality for bread making was germinated bean flour (15-20%) whereas the lowest level was obtained for germinated lentil flour (5-7.5%). For the rest of germinated flour analyzed an addition level of 10-15% is recommended for obtain a high quality bread. More, different mixes between germinated legumes flours may be used to obtain bread of a high quality (a mix between 5.60% germinated soybean flour and 3.62% germinated lupine flour and a mix between 8.57% germinated chickpea flour and 5.31% germinated lupine flour) were optimal ones from the technological point of view. Also, was obtained very good results from mixes between germinated legumes flours from lupine, soybean and bean and mixes between germinated legumes flours such as lentil, chickpea and bean which were described in patents applications filed submitted for evaluation to OSIM. Also, a mix obtained from all germinated legumes flours obtained was recommaned for the use in bread making in a patent application filed submitted for evaluation to OSIM. Almost all the data obtained have been disseminated through publications in different international journals (mostly ISI in Q1 or Q2 category), patents applications, conference disseminations, etc. as fallowing: 9 articles in ISI journals (from which 6 in Q1 category and 2 in Q2 category), 1 BDI article (SCOPUS indexed), 1 BDI article accepted for publication, 3 patents applications filed submitted for evaluation to OSIM and 12 participation with presentation to different conferences (1 with the industrial participation - RO.aliment SHOW, fifth edition, 17-21 may, oral presentation- after the presentation Millbo company contact us for a collaboration).

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