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.

For the ***first stage*** of the project (period November 2020-December 2020) the ***abstract*** was:

The technological characterization of the wheat flour that wants to be used in the experiments (a strong or a very good one for bread making quality which will be the raw material that will be used in the experiments): moisture, ash, wet gluten content, index of gluten deformation, falling number index

For the ***second stage*** of the project (period January 2021-December 2021) the ***abstract*** was:

The physical-chemical characterization of the wheat flour and legumes that wants to be used in the experiments; Obtaining of the germinated flours from legumes chosen to be used in experiments; Physico-chemical characterization of the composite flours obtained; Physico-chemical and microbiological characterization of the germinated legumes flours obtained; Empirical rheological characterization of dough obtained from composite flours.

The main objectives of the project TE158/2020 during the period November 2020-December 2021 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 (empirical ones) of composite flours.

The activities related to these objectives with specific results during the period November 2020-December 2021 according to the ***Annex II of Contract*** No. TE158/2020 were:

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 (period November 2020-December 2020);

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 (period January 2021-December 2021);

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 (period January 2021-December 2021) ;

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 (period January 2021-December 2021);

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 (period January 2021-December 2021);

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 (period January 2021-December 2021);

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 (period January 2021-December 2021);

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 (period January 2021-December 2021);

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 (period January 2021-December 2021);

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 (period January 2021-December 2021);

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).

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 empirical rheological properties of the mix from composite flours;

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 a single or different combinations) according to ICC 107/1 method;

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

The dough empirical rheological properties of the mix from the composite flours were made by using the Alveo Consistograph (Alveograph and Consistograph part) and Rheofermentometer 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 determined with the Alveo Consistograph (Chopin Technologies, Cedex, France) device (Alveograph part) were made 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 druing fermentation of the mix from the composite flours determined with the Rheofermentometer device (Chopin Rheo, type F4, Villeneuve-La-GarenneCedex, France) were made 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, %)

2. Results and discussions

For the research objectives proposed in **Annex II of Contract** No. TE158/2020 during the period November 2020-December 2021 the following results were obtained:

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 (empirical ones) of composite flours

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 (7 ISI from which 4 published, 2 accepted, 1 under review),
	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.	8 papers presented to different conferences.
	A2.4. Physico-chemical characterizations of germinated legumes flour obtained: humidity, ash, acidity, proteins, lipids, amino acids and mineral content.	
	A2.5. Microbiological characterization of germinated legumes flour obtained: yeast molds, mycotoxins.	
O2. Production of germinated legumes flours	A2.3. The production (establishing the working protocol) of germinated flours from legumes: lentil, chickpea, soybean, lupin, bean.	The data about the production of germinated flours from legumes were published in 2 ISI articles and 3 patent applications filed submitted for evaluation to OSIM, 2 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 under publishing of 1 paper presented to a conference.
O4. Evaluation of rheological properties (empirical ones) 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 empririal dough rheological properties obtained from composite flours were presented in 3 ISI articles (1 published, 1 accepted, 1 under review), 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.	
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:** - 4 articles published in ISI journals from which 3 in Q1/Q2 category; - 3 patent 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); - 3 articles being evaluated in journals indexed/quoted ISI (2 in Q1/Q2 category) from which 2 accepted to publication.	**Obtained results:** ***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 2,474, ***category Q2*** , 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 2.762, ***category Q1***, 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 4.35, ***category Q2***, accession number: WOS: 000676853800001 Available online: https://www.mdpi.com/2304-8158/10/7/1542 ***II. Patent applications filed submitted for evaluation to OSIM*** 1. Codină G.G., Mironeasa S., Atudorei D., Muşu A., Ungureanu-Iuga M., Oroian M.A., Functional flour from germinated legumes for baking and process for obtaining it, A/00570 2. Codină G.G., Mironeasa S., Atudorei D., Muşu 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., Muşu 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 ***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., 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*, XXI[th] 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 şi Ştiinţa Alimentelor, Târgovişte ***IV. Articles being evaluated in journals indexed/quoted ISI*** 1. Iuga-Ungureanu 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 2,474, ***Q2 category***, accepted for publication 2. Iuga-Ungureanu M., Atudorei D., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy, impact factor 3,417, ***Q1 category***, under review 3. Codină G.G., Iuga M., Stroe S.G., Mironeasa S., Chemical characterization of wheat-germinated legumes composite flours, accepted for publication in Conference Proceedings (ISSN 1314-2704) of the XXI[th] International Multidisciplinary Scientific GeoConference Surveying, Geology and Mining, Ecology and Management – SGEM 2021 which will be indexed in different databases such as ISI Web of Science - Clarivate, ELSEVIER products - SCOPUS, Mendeley and COMPENDEX, CrossRef, SPRINGER Nature, EBSCO, ProQuest, RSCI (Russian eLibrary - РИНЦ), Google Scholar, CiteULike

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 – period November 2020-December 2020**) 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 4 articles and 5 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 4.35, ***category Q2***, 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-December 2021.

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 2.762, ***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*, accepted for publication in Conference Proceedings (ISSN 1314-2704) of the XXIth International Multidisciplinary Scientific GeoConferenceSurveying, Geology and Mining, Ecology and Management – SGEM 2021

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*, accepted for publication in Conference Proceedings (ISSN 1314-2704) of the XXIth International Multidisciplinary Scientific GeoConferenceSurveying, Geology and Mining, Ecology and Management – SGEM 2021

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 2.762, ***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 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 4.35, ***category Q2***, accession number: WOS: 000676853800001

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

2. Iuga-Ungureanu 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 2,474, ***Q2 category***, accepted for publication

3. Iuga-Ungureanu M., Atudorei D., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy, impact factor 3,417, ***Q1 category***, under review

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 most of them published/under process of publication. The data may be seen in the published/under process of publication articles available in the UEFISCDI system – the articles in extenso are loaded (are or will become public data) 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 wants to be published in the next year (2022). From the amino acids point of view, according to the data obtained 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.

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 2.762, ***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., Muşu 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 2.762, ***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 4.35, ***category Q2***, accession number: WOS: 000676853800001

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

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*, XXI[th] 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 şi Ştiinţa Alimentelor, Târgovişte

III. Articles being evaluated in journals indexed/quoted ISI

1. Iuga-Ungureanu 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 2,474, ***Q2 category***, accepted for publication

2. Iuga-Ungureanu M., Atudorei D., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy, impact factor 3,417, ***Q1 category***, under review

3. Codină G.G., Iuga M., Stroe S.G., Mironeasa S., Chemical characterization of wheat-germinated legumes composite flours, accepted for publication in Conference Proceedings (ISSN 1314-2704) of the XXI[th] International Multidisciplinary Scientific GeoConference
Surveying, Geology and Mining, Ecology and Management – SGEM 2021

which will be indexed in different databases such as ISI Web of Science - Clarivate, ELSEVIER products - SCOPUS, Mendeley and COMPENDEX, CrossRef, SPRINGER Nature, EBSCO, ProQuest, RSCI (Russian eLibrary - РИНЦ), Google Scholar, CiteULike

O2. Production 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 2.762, 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., Muşu A., Ungureanu-Iuga M., Oroian M.A., *Functional flour from germinated legumes for baking and process for obtaining it*, A/00570

2. Codină G.G., Mironeasa S., Atudorei D., Muşu 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., Muşu 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

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 2.762, ***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., Muşu A., Ungureanu-Iuga M., Oroian M.A., *Functional flour from germinated legumes for baking and process for obtaining it*, A/00570

2. Codină G.G., Mironeasa S., Atudorei D., Muşu 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., Muşu 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

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*, accepted for publication in Conference Proceedings (ISSN 1314-2704) of the XXIth International Multidisciplinary Scientific GeoConference Surveying, Geology and Mining, Ecology and Management – SGEM 2021.

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 most of them are presented in the article accepted/under process of publication. The data may be seen in the accepted/under process of publication article mentioned above available in the UEFISCDI system – the article in extenso are loaded (will become after publication public data) where the results obtained are discussed in a very extensive way.

The data on the amino acids content of the composite flours obatined have not been published yet but these data wants to be published in 2022 in an article. 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 paper which was accepted and it is under process of publication and presented to the fallowing conference:

Conference participations with the publication (article accepted being in the print process) of the article presented

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/

The article will be published in the Conference Proceedings (ISSN 1314-2704) of the XXIth International Multidisciplinary Scientific GeoConference Surveying, Geology and Mining, Ecology and Management – SGEM 2021 which will be indexed in different databases such as ISI Web of Science - Clarivate, ELSEVIER products - SCOPUS, Mendeley and COMPENDEX, CrossRef, SPRINGER Nature, EBSCO, ProQuest, RSCI (Russian eLibrary - РИНЦ), Google Scholar, CiteULike

O4. Evaluation of rheological properties (empirical ones) of composite flours (activities A2.7, A2.8, A2.9).

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 poin of view (amylase in especiall the alpha amylase one).

The empirical dough rheological properties data during mixing (activity A2.7), extenstion (activity A2.8) and fermentation (activity A2.9) of composite flours (mix of wheat flour and germinated flour from lentil, chickpea, soybean, lupin, bean in a single or different combinations addition) may be seen in the articles 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 4.35, ***category Q2***, accession number: WOS: 000676853800001

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

2. Iuga-Ungureanu 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 2,474, ***Q2 category***, accepted for publication

3. Iuga-Ungureanu M., Atudorei D., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy, impact factor 3,417, ***Q1 category***, under review

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 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.

In the ***article no. 2*** 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). 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.

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 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. 3*** 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%.

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, and initial gelatinization temperature 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 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 have been achieved and most of them are published/under process of publication. The data may be seen in the published/under process of publication articles available in the UEFISCDI system – the articles in extenso are loaded (are or will become public data) where the results obtained are discussed in a very extensive way (the singular effect of germinated bean flour, germinated lentil flour, germinated soybean flour 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 empirical dough rheological properties during mixing, extension, fermantation and also falling number value).

However, the effect of germinated chickpea flour and germinated lupin flour in a singular addition on empirical dough rheological properties have not been published. These data wants to be published next year (2022) along with bread quality characteristics. According to our data obatined, CGF 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 LGF (up to 247 s) incorporation. Dough mixing behavior in terms of water absorption, and dough conistency parameters showed significant reduction as the amount of CGF raised, while dough tolerance to kneading varied irregularly. Similar reduction trends of water absorption and dough consistency values were observed for LGF 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 CGF or LGF were higher and compared to the control. Dough tenacity increased as the amount of LGF raised, while CGF determined an irregularly variation. The Alveograph curve configuration ratio values also increased proportional with CGF or LGF addition level. All the parameters listed above were influenced significantly ($p < 0.05$) by CGF or LGF incorporation. On dough empirical rheological properties during fermentation, the maximum height of gaseous production, total CO_2 volume production increased up to 10% CGF or LGF 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 LGF and CGF addition while the retention coefficient varies irregularly.

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

I. Articles published in journals indexed/quoted ISI

Atudorei D, Atudorei O, Codină G.G., 2021, *Dough rheological properties, microstructure and bread quality of wheat-germinated bean composite flour*, Foods, impact factor 4.35, ***category Q2***, accession number: WOS: 000676853800001

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

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 şi Ştiinţa Alimentelor, Târgovişte

III. Articles being evaluated in journals indexed/quoted ISI

1. Iuga-Ungureanu 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 2,474, ***Q2 category***, accepted for publication

2. Iuga-Ungureanu M., Atudorei D., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy, impact factor 3,417, ***Q1 category***, under review

Dissemination of research results. According to the Annex II of Contract No. TE158/2020 during the period November 2020-December 2021 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).

It was achieved much more that was propose to as fallowing: 4 articles published in ISI journals from which 3 in Q1/Q2 category; 3 patent 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); 3 articles being evaluated in journals indexed/quoted ISI (2 in Q1/Q2 category) from which 2 accepted to publication.

As it may be seen, all the dissemination of the research results have been done according to the **Activity 2.10**.

During the period November 2020-December 2021 the results obtained during this project have been disseminated 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 2,474, ***category Q2*** , 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

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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 2.762, ***category Q1***, 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 4.35, ***category Q2***, 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., Muşu A., Ungureanu-Iuga M., Oroian M.A., *Functional flour from germinated legumes for baking and process for obtaining it*, A/00570

2. Codină G.G., Mironeasa S., Atudorei D., Muşu 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., Muşu 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

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., 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 şi Ştiinţa Alimentelor, Târgovişte

IV. Articles being evaluated in journals indexed/quoted ISI

1. Iuga-Ungureanu 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 2,474, ***Q2 category***, accepted for publication

2. Iuga-Ungureanu M., Atudorei D., Codină G.G., Mironeasa S., 2021, Germinated chickpea and lupine as promising ingredients for breadmaking – rheological features, Agronomy, impact factor 3,417, ***Q1 category***, under review

3. Codină G.G., Iuga M., Stroe S.G., Mironeasa S., Chemical characterization of wheat-germinated legumes composite flours, accepted for publication in Conference Proceedings (ISSN 1314-2704) of the XXIth International Multidisciplinary Scientific GeoConferenceSurveying, Geology and Mining, Ecology and Management – SGEM 2021 which will be indexed in different databases such as ISI Web of Science - Clarivate, ELSEVIER products - SCOPUS, Mendeley and COMPENDEX, CrossRef, SPRINGER Nature, EBSCO, ProQuest, RSCI (Russian eLibrary - РИНЦ), Google Scholar, CiteULike

Conclusions

All the research objectives proposed in Annex II of Contract No. TE158/2020 during the period November 2020-December 2021 was completed and was achieved. In the period November 2020-December 2020 has been performed only the activity A1.1 of which results have been published in all articles in which wheat flour was used as base material in our experiments. The rest of the data according to the activities A2.1-A2.9 was performed in the period January 2021-December 2021. 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. Almost all the data corresponding to the activities from this period of time have been published or are under process of publication (in the articles may be seen the data obtained which are presented and discussed in an extensive way) or presented to different conferences as fallowing: 4 articles published in ISI journals from which 3 in Q1/Q2 category; 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); 3 articles being evaluated in journals indexed/quoted ISI (2 in Q1/Q2 category) from which 2 accepted to publication (all the articles in extenso are loaded into the UEFISCDI system to the articles section). Also 3 patent applications filed was submitted for evaluation to OSIM.

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