PHD THESIS SUMMARY

Study of quality parameters of bakery products obtained from legums fortified flour

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INTRODUCTION

In our country a person consumes on average about 100 kg of white bread annually. In the process of obtaining Bread from flour type 480, 550 or 650, named white flour due to the extraction rate between 0-30%, having a very low degree of extraction, all beneficial substances (bran, germs) are largely lost. In turn, food fibers, renowned for their nutritional value, are eliminated almost completely. Thus, white flour is very poor in vitamins, minerals, protein, and fiber. We know that the essential amino acids, which are found in whole grain wheat can not be synthesized by the body for which arises the major need to be received through food. For this, it is important to know that as far as the flour is finer and whiter, also the essential amino acids in wheat proteins are also in smaller numbers; (SLUIMER P 2001).

WHO and FAO, among many other nationally accepted organizations have recognized that there are over 2 billion people in the whole world suffering from a variety of micronutrient deficiencies. So far, over 50 countries have adopted national mandatory strategies for fortification of wheat flour and durum wheat flour through the addition of ferrous fumarate (C4H2FeO4) and folic acid (pteroyl monoglutamic), synthetic form of iron and folate (tetrahydrofolate).

According to research done by Svetlana (2010), the most effective and affordable way to ensure the population with vitamins and micronutrients is additional fortifying daily consumption food, particularly flour and bakery products with these substances. Food fortification should not diminish the nutritive quality, in particular should not alter the taste or absorption of other essential nutrients contained in them, should not reduce the shelf life, nor alter the characteristics of the product harmlessness.

Incorporation of lentils in food products has been the subject of much research and resulted in a variety of possible utility of lentils in food (Boye et al., 2010). Products based on cereals and include bread or bakery products, pasta and noodles are very promising (Gomez et al., 2003; Li & Vasanthan, 2003; Zhao et al., 2005; Anthony et al., 2008a; Bildstein et al., 2008). Extruded and fried snacks are also suitable for such utilities (Annapure et al., 1998; Thakur & Saxena, 2000; Anthony et al., 2008; Anthony et al., 2009a; Ryland et al., 2010).

The results regarding the possibilities of using lentil flour mixed with wheat flour in the production of bread has confirmed the current trend of traditional enrichment. Experimental bread made from mixture of wheat flour and lentil flour presented in comparison with normal bread, has a smaller volume. However, in terms of nutrition has a higher content of proteins with an appropriate structure and a higher content of essential mineral for the human body which shows that the obtained bread was significantly improved. (ANTON, Aşi et al. 2008).

Lentil flour increases the nutritional value of bread, but also modifies the rheological properties of dough and, finally, sensory quality. However lentil flour is a common ingredient and with potential in developing of a new generation of healthy food (MAN AND Paucean 2013).

The research in this paper were conducted in the Food Quality Control laboratories, Laboratory LICSA, Laboratory AGRIFAL within Faculty of Food Science and Technology, University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, analyzes concerning the content of the micro and macro elements, amino acids and rheological laboratory were conducted in Bakery and Rheology lab and the Platform for Interdisciplinary Research in the Faculty of Food Technology of USAMV Banat.
AIM AND OBJECTIVES

AIM OF THE THESIS

Research conducted in the thesis „Study of quality parameters of bakery products obtained from legumes fortified flour“, aimed at identifying optimal dosage of legumes (Lens culinaris) in order to fortify white wheat flour to raise nutritional value and its capitalization in bakery products.

OBJECTIVES

In order to accomplish the purpose, were addressed three major research directions, established as the objectives of this thesis:

1. Quantifying the main chemical compounds of wheat flour, lentil flour and composite flours
2. Evaluation of rheological parameters of doughs made from flour fortified with lentil flours (Lens culinaris)
3. Obtaining a functional innovative product for people with special dietary needs

STRUCTURE OF THE THESIS

Thesis entitled "Study of quality parameters of bakery products obtained from fortified flour legumes" is divided into two main parts, the first part "The current state of knowledge in the bakery products made from flour fortified with legumes" including the study of literature and the second part "Original contributions to knowledge development in the field of bakery products made from flour fortified with legumes" including personal contributions, results, conclusions and research perspectives.

PART ONE, "THE CURRENT STATE OF KNOWLEDGE IN THE BAKERY PRODUCTS MADE FROM FLOUR FORTIFIED WITH LEGUMES" is structured in two chapters.

Chapter I. FOOD FORTIFICATION comprises 5 chapters which present the results obtained after an extensive literature study, namely: the current situation of nutritional deficiency globally, classes of consumers who need special nutrition, the importance of food fortification, products which lend themselves to fortifying and ways of the fortification process.

Chapter II. PRESENTATION AND CHARACTERIZATION OF LEGUMES describes in its four chapters general concerning regarding pulses that can be added whole or fractionated in some foods, global production and chemical composition of pulses. Studies show that lentil is a plant used in the diet of Asian and Mediterranean population. By analyzing the chemical composition, lentil was labeled as grade A food due to high nutritional fiber, iron, magnesium, phosphorus, protein and very low fat content.

Analyzing lentil consumption compared with wheat flour in Romania and the medical benefits of lentils, has been studied the possibility of integrating lentil in a innovative functional product dedicated to certain classes of consumers.

PART TWO, PERSONAL CONTRIBUTION is structured in four chapters.

Chapter III. AIMS AND OBJECTIVES, includes the purpose and specific objectives of the thesis.

Chapter IV. MATERIALS AND METHODS USED focuses on presenting the material and three experimental work protocols related to research in the eight subchapters of it.
Chapter V. RESULTS AND DISCUSSION disseminates over three subchapters results on the analysis of composite flours, composite doughs rheology, samples of bread and their statistical interpretation.

Chapter VI. CONCLUSIONS AND RECOMMENDATIONS presents findings that emerged from studies in the doctoral thesis entitled "Study of the quality parameters of bakery products made from legumes fortified flour and fulfilling the three objectives of the thesis, followed by recommendations.

PERSONAL CONTRIBUTIONS
CHAPTER III. MATERIAL AND METHODS

3.1 BIOLOGIC MATERIAL
The biological material used to carry out experiments consists of red and green lentil samples (Lens culinaris) - Fig. 1, samples of wheat flour - Fig. 1, flours composite - Fig. 2, samples of dough - fig. 3 and the finished product represented by the samples of bread – Fig. 4.

Fig. 1. Experimental material: a - red lentil flour, b - green lentil flour, c - wheat flour.

In this study we examined two types of lentils and a type of wheat flour, namely: wheat flour type 650 - Fig. 1.c, Red lentil flour - fig. 1.A and green lentil flour- fig. 1.b
Mixtures containing 10%, 15%, 20% and 30% respectively red and green lentil flour (as a percentage replacement of wheat flour) were called composite flours.

Composite flours obtained were stored in a plastic container at room temperature until their use - (Figure 2).
3.2 METHODS
In order to achieve the proposed objectives were modeled three experimental protocols, structured according to three major research directions.

3.2.1. Compositional study of wheat flour, of lentil flour (Lens culinaris) and also of their various mixes
To achieve this goal was pursued experimental protocol depicted in Figure 4.

- nutritional assessment of the main parameters of wheat flour, lentil flour (Lens culinaris) and composite flours, applying various physicochemical methods and NIRS technique.
- quantifying the amount of essential amino acids and micro/ macro elements by chromatographic and spectrophotometric techniques in obtained composite flours, lentil flours and control sample.
- identifying and quantifying fatty acids and aroma compounds from wheat flour and lentil flour (Lens culinaris) by the GS-MS or HS / ITEX / GS-MS technic.

3.2.2 Evaluation of rheological parameters of doughs made from flour fortified flour lentil (Lens culinaris)
To achieve this goal and to achieve a more conclusive picture of the quality of dough obtained from composite flour, the samples were analyzed by different rheological methods listed in Fig. 5 using latest equipment, generating accurate results.
3.2.2. Obtaining an innovative functional product (for people with special dietary needs)

In order to achieve this goal was pursued experimental protocol of FIG. 6. According to him, have been developed following specific objectives:

- Valorisation of composite flour in the bread and optimization of the fortified bread-making recipe.
- Assessment of finished products obtained from a nutritional, physico-chemical, microbiological and psycho-sensory standpoint.
- Assessing the influence of the legumes flour parameters followed by statistical analysis (ANOVA).
- Discrimination of samples by statistical analysis.
CHAPTER IV. RESULTS AND DISCUSSIONS

4.1 RESULTS AND DISCUSSION REGARDING THE COMPOSITE FLOUR

This section presents the results on the samples represented by composite flours studied as feedstock. On them univariate statistical analysis (ANOVA1) was applied complemented by Tukey significance test.

By statistically centralizing the multitude of results obtained in this part of the thesis may be noted that with the increasing ratio of lentil flour added, there is a significant increase in ash content in minerals, protein, in amino acids, in total lipid, in essential fatty acids (and hence acidity), in sugars, in fiber and a decrease in moisture, in the percentage of starch compared to the resulting composite whole wheat flours. These differences grow in the studied mixes in commensurate with the growth ratio of lentil flour mixture.

Analysing the differences between the chemical composition of red and green Lentil flour has stands out the fact that red lentil flour has a higher content in minerals, protein, essential fatty acids, starches, sugars and lower content in ash, fat, fiber. In terms of amino acids and moisture content the differences between the two types of lentil flours are negligible.

4.2 RESULTS AND DISCUSSION REGARDING THE COMPOSITE DOUGH RHEOLOGY

In this subchapter were disseminated results achieved under the second objective, namely, analyzing rheological dough obtained from composite flours proposed for analysis. The results obtained in the flour cases with the addition of red and green lentil in 10%, 15%, 20%, 30% were compared with those of a control sample of the wheat flour. In order to see the differences between the 9 samples a Tuke statistical analysis was used, complemented by Pearsons linear regression, in order to see the differences and similarities between samples.

Comparing the results obtained in the composite flours cases analyzed, it was observed that by increasing ratio of lentil flour added (10%, 15%, 20% and 30%), the hydration capacity also increases in the flour mixes studied. Increasing the moisture with 1-4% capacity is determined by increasing the quantities of protein and dietary fiber with the addition of Lentil flour in the above mentioned reports.

For doughs obtained with the addition of red lentils, was highlighted a strong connection between the amount of lentil added and the dough time formation. At a rate of 10% -15% red or green lentil added, dough time formation was 2-3 minutes over the control sample and samples of dough with the addition of 30% red lentils and green lentils were twice and a half higher for red lentils and three times higher for green lentils.

With the addition of lentil flour changes and soaking properties of the dough. It notes that the soaking was influenced in a large proportion by the increased percentage of lentil flour.

The behavior of the dough during mixing is given by: (WA%) wich represents the hydration property of flour required to reach a torque of 1.1 Nm and (ST min.), which is the torque holding time of 1, 1 Nm. Results in tests show that with increasing ratio of lentil flour also added increased the value of WA from 57.18% FM (control flour) up to a maximum of 61.50% for FLV (flour with added green lentils) 30% and 59.20% in FLR (flour with added red lentils) 30%, but also the stability of dough decreases to a minimum of 5.48 min. FLR 30% and 6.42 min. FLV 30%, stability indicating a plasticity almost 2 times lower than FM. Changing representative times
in the dough stability is due to the intake of fiber and nongluten protein disturbing the existing network of FM. The parameters which measure the gelatinization of the starch, the enzyme activity and rate of β starch gelatinization are characterized by a inversely proportional decrease by the percentage of Lentil flour, added because the starch content thereof is lower than the wheat flour.

With the rise of the Lentil flour percentage added, retention of the gas capacity decreases, the main reason being that Lentil flour is gluten-free protein and has a higher content of fiber. Differences between the fortified samples with red or green lentil are due to the fact that red lentils has a higher protein content than green lentils. A difference two times higher in the samples of flour fortified with 10% and 15% lentil red or green, and in the samples fortified with a 30% green or red lentils the difference is 4 times lower than the control sample.

α-amylase activity has a maximum of 350 s for control sample and a minimum of 97 s for red lentil flour and 221 s for green lentil flour. According to STAS SR ISO 3093/1997 samples with an α-amylase activity framed between 220-280 ic limits are considered flours with normal enzyme content and in this range falls only FLV100% green lentils sample. The other samples are hovering beyond the ic <160 s and are classified as samples containing high α-amylase.

Note that with the addition of red and green Lentil flour the doughs gluten percentage decreases from 28.5% percentage in FM to a minimum of 20.3% in FLV30% and 21.2% in FLR30%.

4.3 RESULTS AND DISCUSSION ON SAMPLES OF BREAD

This chapter presents the results on the four prototypes of functional bread made from a mixture of wheat flour (type 650) with flour, lentil red and / or green 10%, 15%, 20% and 30%. To highlight the advantages and / or disadvantages fortifying flour and samples include bread obtained exclusively from wheat flour (PL0%), considered blank.

Bread samples studied show a moisture content between 41% and 45%. Bread made from 100% wheat flour has a recorded humidity significantly lower than composite samples obtained from fortified flours, their humidity increases significantly with the increase ratio of the flour lentil.

Also, after statistical analysis variance (ANOVA) of data was noted a moisture content significantly higher (p <0.01) in samples of bread obtained by fortification of wheat flour with green lentils, compared to those obtained by red lentil flour fortification.

Like moisture, ash content is influenced by a very large proportion (98.04% and 96.22%) by the increase of the ratio of Lentil flour added. The highest ash content is highlighted in the bread made from composite flour fortified with 30% green lentils flour.

Of the seven mineral elements determined (calcium, iron, potassium, zinc, magnesium, manganese and copper) control sample has the lowest amount, while samples fortified with 30% Lentil flour (red and green) recorded an amount 4 times higher. In general, at the same ratio of flour Lentil, bread from green lentils flour recorded a higher content of mineral elements. In the finished product bread samples was identified a lower content of proteins compared to their corresponding flours samples.

The amount of both essential and nonessential amino acids increases with the increasing ratio of flour lentil, and the differences between the two types of lentils are negligible.

It is noticed a significantly lower lipid content in bread from wheat flour and a higher content of lipids in fortified bread, the differences being still significant from 10% ratio. At the same ratio of the Lentil flour, there is a significantly higher fat content inf products containing green lentils.
A large proportion of polyunsaturated fatty acids identified in all the samples of bread are of the $\omega$-6 type, leading to a fatty acid ratio of $\omega$-6 / $\omega$-3 higher than that what is considered to be optimal in the literature.

The starch content of bread samples decreases with the increase of the amount of Lentil flour, introduced into the composition. In general, at the same ratio of Lentil flour, bread from green lentil flour recorded a slightly higher starch content than the bread from red lentil flour.

Like the starch content, sugar content of the samples of bread decreases with increasing amount of Lentil flour inserted into their composition. The sugar content is 6.7% in blank and decrease gradually, reaching 1.16% in bread with 30% flour green lentils. The Correlogram obtained is described by a straight line regression with a slope downward, which confirms the inverse linear relationship between the content of high intensity Lentil flour and sugars.

For all flour lentil studied reports, bread from green lentil flour recorded a significantly lower sugar content than bread from red lentil flour.

It was noticed the low fiber content of the control sample, while in the bread with fortified Lentil flour, fiber content was significantly improved (p < 0.001) from the ratio of 10%, registering a fiber content 8 times higher than control sample at the bread with 30% Lentil flour. In general, there is a higher fiber content in bread fortified with green lentils.

There is a lower acidity in the bread produced exclusively from white wheat flour and high acidity in the bread fortified with lentil flour. With the ratio increase of lentil flour increases the acidity of the finished products. At the same ratio of the Lentil flour, bread fortified with green lentils flour recorded a higher acidity than bread fortified with red lentils flour.

Sensory profile of bread, namely, the flavor profile is enhanced with the introduction of new ingredients in its composition, in this case, with red and green Lentil flour to supplement the product with.

Lentil flour is rich in fiber, minerals, protein, and adding the flour will have a decisive influence on its technological parameters, reflected in quality of bread - finished product. Adding Lentil flour in bakery products has main effect in lowering their elasticity.

An advantage of the addition of fibers is that increases the productivity, since it increases the capacity of hydration of the flour, therefore, from the same amount of flour can be obtained a greater number of products.

Another advantage is that the fibers are more able to retain water in the final product, thus reducing the rate of staling (Horimoto et al., 1995).

By comparison with the control sample, was observed that in the prototypes of bread with red lentils flour has been a slight increase in the total number of yeasts and molds, due to the higher percentage of water that provides microorganisms favorable conditions for development.

In prototypes with green lentil flour was noticed a decrease of yeasts and molds, with the percentage increase of green lentil in bread.
CHAPTER V

CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

5.1. CONCLUSIONS ON THE COMPOSITE FLOUR

Following the analysis performed in the first direction of research "Study of wheat flour, of the flour of legumes (Lens culinaris), and their different mixes, from compositional aspect stood out the following:

Lentil flours, both red and green, physicochemical properties significantly different from white wheat flour.

In general, lentil flours record a higher content in protein (27.2%), ash (2.46%), fiber (4.8%), fat (2.02%), minerals (Cu, Mg, Mg, Zn, Fe, Ca and K), essential amino acids (lysine, valine, threonine, leucine, isoleucine and threonine), essential fatty acids (oleic and linoleic), giving a better ratio of fatty acid ω-6 / ω-3 (4.69 to 100% PLR). However, Lentil flour shows low water content (11%) and starch (57.2%), and a higher acidity (7.7 acidity degrees) than wheat flour (2.8 acidity degrees).

Between the two types of lentil flour studied were also noted significant differences. Green lentils Flour presents a higher content of fiber, essential amino acids and polyunsaturated fatty acids ω-3, showing also the lowest energy value, while red lentils flour registered an increased content in protein, sugars and minerals and also a higher acidity.

In the case of composite flours studied, differences between the two types of lentil are not so obvious, they become meaningful only to the ratio of 20% and 30%. Instead, what is observed is a significant improvement in physico-chemical parameters, with increasing the substitution ratio in Lentil flours, which certifies that Lentil flour can be used to fortify wheat flour.

In order to capitalize the Lentil flour as an ingredient in baking, was intended to portray its flavor through the study of volatile compounds.

Using the technique ITEX / GC-MS were separated and identified a number of 9 representative volatile compounds from alcohols, aldehydes and ketones class, all identified in flour test sample and also found in samples of lentil. The main flavor compounds identified in analyzed flours are from alcohols Class (74.62 - 37.06%).

In urma analizelor fizico chimice realizate pe făinurile compozit, prototipurile care se pretează cel mai bine pentru a fi încorporat în produsele de panificație din punct de vedere al acestora este făina compozit cu un raport de substituție al făinii de linte verde dar și roșie de 20 și 30%, deoarece în aceste făinuri compozit toate rezultatele obținute pentru parametri nutriționali și de calitate au avut valorile cele mai apropiate de necesarul zilnic de nutrienți necesari organismului uman pentru o bună dezvoltare și funcționare.

Following physico chemical analyses performed on composite flours, prototypes best suited to be incorporated into bakery products are flour composites with a degree of substitution of green and red lentils flour 20% and 30%, because in these composite flours all results for nutritional and quality parameters had values closest to the daily requirements of nutrients necessary for proper body development and functioning.
5.2. CONCLUSIONS ON THE COMPOSITE DOUGH RHEOLOGICAL PARAMETERS

Following the analysis carried out in the second direction of research "Evaluation of dough rheological parameters obtained from fortified flour with legumes flours (Lens culinaris)" have been noted the following:

With increasing degree of substitution of wheat flour with Lentil flour doughs hydration capacity is increasing from a minimum of (58.9%) in the test sample up to a maximum of (62.5%) for sample 30% with lentil flour. This increase is due to the high content of fiber and protein having a hydrophilic character.

Another important parameter changed considerably with the rise of substitution ratio is the development time of the dough which for the test sample was 2 minutes and 30%Lentil flour sample increase to 6.1 minutes, and is due to hydration slower due to high fiber content.

While the development of the dough increases with the decrease of the percentage substitution, its stability decreases from a maximum of 4.4 minutes to a minimum of 2.2 minutes. Parameters showing the deformation of the dough recorded in turn a significant decrease, in specific maximum pressure decreased from a maximum of (75 mm) to a minimum (39 mm) when extensibility decreases from a maximum (93 mm) at a only the minimum (28 mm).

Aelvograph recorded a decrease when performing analyzes on composite flours from a maximum of (21 cm$^3$) reported for the test sample to a minimum (11.6 cm$^3$) reported for the samples with 30% of lentil flour.

Parameters who recorded declines with the increase ratio of substitution of wheat flour with Lentil flour are: Strain energy which decreases from a maximum ($229 \times 10^{-4}$ J) in the control sample to a minimum of only ($32 \times 10^{-4}$ J) for samples fortified with 30% Lentil. Other parameter that recorded a major fluctuation was enzymatic activity which decreases from a maximum of 350 seconds for the test sample to a minimum of 97 seconds for Lentil analyzed samples.

The addition of the Lentil flour rich in protein and fiber negatively influence the network of gluten because, with the introduction of legumes flour in the network of gluten in different percentages of substitution, reduced the percentage of protein gluten (gliadin, gliadin) by replacing them with nongluten protein (albumin, globulin) and high fiber quantity disrupts the gluten network making it impossible for gas detention at a substitution ratio higher than 20% lentil flour. Wet gluten amount recorded in the control sample was 28.5% while the amount of wet gluten samples registered a 30% lentil was only 20.3%.

Following the rheogical analysis conducted on composite flours was observed that prototypes that are best suited to be incorporated into bakery products in terms of rheology are flours composite with a degree of substitution of green and red 10-15% lentil flour.

5.3. CONCLUSIONS ON BREAD PROTOTYPES

Unlike conventional foods, functional food technology has an additional objective, namely, to identify, quantify and optimize the functional role of bioactive components, and monitor their effectiveness in the finished product. Thus, following the objectives of the third research directions, "Obtaining an innovative functional products for special nutrition" were formulated the following conclusions:

Bread with lentil obtained is a natural product with no added preservatives, flavors and dyes, synthetic, with controlled intake of nutrients, intended for broad categories of consumers both healthy individuals concerned about maintaining health, and persons suffering from mild digestive tract, diabetes, hypertension, overweight.

Using the Lentil flour in order to achieve bakery products, is not raising technology issues and the products can be processed on conventional production lines model, in the existing bakery units.
Following the analysis carried out in the framework of the third direction of research was noted that the ratio of the Lentil flour in composite flour used for the production of bread as a finished product influences in a very high proportion (90%) the studied parameters, Pearson correlations showing strong and very strong links between them.

It revealed a direct link between the proportion of the Lentil flour and moisture content, ash, protein, fat, fiber and acidity of bread as a finished product and a reverse link, strong between the proportion of the Lentil flour and carbohydrate content, and porosity, elasticity and the H/D ratio of bread samples studied.

Thus bread obtained exclusively from wheat flour recorded a significantly less moisture, ash, minerals, proteins, amino acids, fat, fiber content and a lower acidity to bread from fortified lentils flour, contents of these parameters increases significantly with a higher share of lentil in the flour.

At the opposite pole is the content of carbohydrates: sugars, respectively starch, which recorded higher values in bread from wheat flour, their content gradually decreasing with increasing substitution ratio of composite flour with lentil flour. Similar is the case of elasticity, porosity and height-diameter ratio (H/D) which records the highest values in control sample and lowest values in 30% flour bread with lentil.

An important criteria in of the Lentil flour is the effect on flavor profile of the finished product (bread), aiming in this regard, volatile compounds in samples of bread studied using HS/ITEX/GC-MS technique.

With red and green Lentil flour supplement, in breads has been recorded an enrichment in flavor profile, main volatile compounds identified based on GC-MS chromatograms as part of the class of alcohols (2-methyl-1-butanol, 3-methyl-1-butanol and 1-hexanol) and corresponding aldehydes class (hexanal and benzaldehyde). These compounds have been identified in a concentration of three to eight times higher in the samples of bread with 30% Lentil flour, compared with the control (bread without addition of lentil).

Following the interpretation of the psychosensorial analysis results was concluded that consumer preference is toward prototypes of bread with 10% and 15% lentils flour, general acceptance of their score is nearly equal to that of the control sample.

In this sense it could be concluded that the addition of the Lentil flour, can improve the physical-chemical parameters of bread, but the ratio of the flour Lentil added is very important, its increase negatively affecting quality parameters (elasticity, porosity, height-diameter ratio, acidity) of bread as a finished product.

Between the two types of lentil studied, were noted some significant differences. Bread with green lentils flour shows a higher moisture, ash, minerals, protein, fat and fiber content, while red lentil bread is registering a higher content of sugars and amino acids.

Regarding the microbiological quality of the bread with lentils, was found that the results fall within the limits of the Romanian Official Monitor, Part I, no. 435 / 22.06.2011 on microbiological and hygiene standards on bakery products, cereal flours and derivatives.

The target group for this product is the pregnant women, children, the elderly, and people suffering from digestive disorders or overweight.

Using Lentil flour in order to achieve bakery products raises no technological problems, which can be processed on conventional production lines model, in existing bakery units.

Bread with lentil can be called functional product because it has a higher percentage of natural nutrients beneficial to human body in many ways and lead to the reduction or prevention of diseases or ailments.
From a nutritional standpoint and commercially, optimal ratio of substitution of red and green lentil flour in wheat flour is 10 and 15%.

5.4 FUTURE RESEARCH DIRECTIONS

Future research directions could be as follows:

- Expanding the range of functional products based on biologically active compounds extracted from Lentil flour.
- Experimental model aimed at optimizing the bakery composite flours based on rheological profiles.

5.5 THE THESIS ORIGINALITY AND INNOVATIVE CONTRIBUTIONS

The original elements of this thesis are:

- Demonstrating that the ratio of the Lentil flour in the composite flour used to make bread as finished product influences in a large proportion (90%) the studied parameters, Pearson correlations indicating strong links between them.

- Highlighting a direct, very strong link between the proportion of the Lentil flour and content in moisture, ash, protein, fat, fiber and acidity of bread as a finished product.

- The results of comparative physico-chemical analyzes demonstrating that bread with green lentils flour presents a higher content of moisture, ash, minerals, protein, fat and fiber, while bread with red lentils is registering a high content in sugars and amino acids.
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