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Baking Quality of Composite Flours

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DECLARATION

I, Bc. Zhansaya Bolatova, testify that this diploma thesis, submitted in partial fulfilment of the requirements for the degree of Master of Science, in the Faculty of Tropical AgriSciences of the Czech University of Life Sciences Prague, is wholly my own work unless otherwise referenced or acknowledged.

Prague,
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Signature

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Abstract

This study evaluated the quality of baking products from composite flours - wheat flours mixed with hemp, quinoa, and soybean flours. Composite flours percentage proportion was 5:95 and 10:90 (5-10% was replaced flour, 90 – 95 % wheat flour). Nutritional, rheological or physical characteristics of the composite flour and baking quality were investigated using farinograph, extensograph, at the same time ash test, falling number, gluten test, moisture test and protein test were conducted. The results show that moisture was rather similar in all the composite flours, contents of ash and protein was higher in each composite flour compared to wheat flour, percent of gluten in each composite flour was very similar to wheat and the volume of baked product was higher in composite flour made out of wheat with quinoa compared to pure wheat product. There was significantly distinction between breads from wheat flour and composite flours baking in the crust colour, crumb holes, shape regularity and appearance. The shape and characteristic crust colour of composite hemp flour was different, had specific smell and taste.

Key words: composite flours, rheological method, baking test, nutritional value.

Abstrakt

Tato studie hodnotila kvalitu výrobků upečených z několika typů kompozitní mouky – pšeničné mouky smíchané s moukou z konopí, merlíku a sóji. Procentuální podíl kompozitních mouk byl 5:95 a 10:90 (5-10% tvořila nahrazená mouka, 90 až 95% pšeničná mouka). Byly zkoumány nutriční, reologické a vybrané fyzikální vlastnosti kompozitní mouky a kvalita upečených produktů (chléb) s použitím běžných reologických technik (farinograf, extensograf), zároveň byla stanovena vlhkost, obsah popelovin, bílkovin a lepku, číslo poklesu a proveden pekařský pokus. Výsledky ukazují, že vlhkost byla stanovena ve všech vzorcích mouk velmi podobně, obsah popelovin a bílkovin byl ve všech kompozitních moukách vyšší než v mouce pšeničné, Také obsah lepku byl ve všech kompozitních moukách velmi podobný mouce pšeničné a při stanovení objemu upečeného produktu byl objem vyšší u produktu vytvořeného z kompozitní mouky z pšenice a merlíku ve srovnání s kontrolním pšeničným produktem. Chléb upečený z různých kompozitních mouk je odlišný od pšeničného v barvě povrchové vrstvy (krusty), tvaru a celkovém vzhledu, nejodlišnější byly produkty vyrobené z kompozitní mouky s přídavkem konopné mouky.

Klíčová slova: kompozitní mouky, reologická metoda, pečící test, výživná hodnota

Абстракт

Бұл зерттеу композиттік ұндардан нан – тоқаш өнімдерінің сапасы бағаланды: қарасора, алабота, соя бұршағы және бидай ұндары сияқты. Олар жергілікті базардан сатып алынған және араластырылды. Композиттік ұндардың проценттік қатынасы – 5:95 тен 10:90 шейін (5 – 10% композиттелген ұнннан, 90-95% бидай ұнынан). Қоректік, реологиялық және физикалық композиттік ұнның сипаттамалары және нан-тоқаш өнімдерінің сапасы зерттелді. Нәтижесінде, қарасора ұнында – 15,1% ақуыз, 13,2% - ылғал бидай ұнында, қалдық – 1,4% құрғақ зат түрінде композиттік қарасора ұнында және 95,7% желімтік бидай ұнында. Ұндардың реологиялық әдісінде 64,5 – 65,6% судың сіңірілуі, қамырдың әзірлеу уақыты 3-4,5 минут аралығында, қамырдың тұрақтылық уақыты - 3,5 – 5 минут, жұмсаратын дәрежесі - 40 – 50 Б.н. болды. Композиттік қарасора ұны мен бидай ұнының айтарлықтай нан – тоқаш өнімдерінің айырмашылығы қыртыс түсінде, ұнтақты тесіктерінде, сыртқы жиеліктерінде және көрінісінде болды. Кескіні және қыртыс түсі сипаттамасы композиттік қарасора ұнында өзгеше, өзіндік ерекше иісі мен дәмі болды. Ол салауатты өмір салтын ұстанатын және қазіргі заманғы немесе ерекше тағамдарды қолданатын адамдар қолдануы мүмкін.

Кілт сөздер: композиттік ұндар, реологиялық әдістеме, пісіру тестб тағамдық құндылығы.

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List abbreviation

BU	Brabender units
Cm	Centimetre
EU	Extensograph units
FAO	the Food and Agricultural Organization of the United Nations
FJ	Mixing tolerance
H	hemp
M	Metre
Mg	miligram
Min	Minute
Ml	millilitre
Mm	milimetr
NRI	Natural Resources Institute
pH	negative log of the activity of the hydrogen ion in an aqueous solution
Q	quinoa
S	soybean
Sec	second
TNO	the Institute for Cereals, Flour and Bread
TPI	Tropical Products Institute
W	wheat
° C	degree Celsius

1 INTRODUCTION

Nowadays, in the world people are consuming a lot of varieties composite flours and there is a high request for various flour mixtures among altogether populations. People experimented with various possible commodities and to try consuming or preparing everything from inedible to edible when they had problem with meal and lean or hunger years in I or II World Wars. It was beginning of composite flour consuming. At the beginning, they were called blends or mixes of the flours. But from 1960 year`s scientific term of blends is composite flours. Composite flour is mixing or replacing of types flours as with or without wheat. It can be replace with tuber, root, cereals, legumes, nuts and wood or berries flours. Composite flours have great value of nutritious and it can be helpful some peoples which have problem with health. Baking from composite flour of mixing other forms with wheat flour has two causes such as nutritional and economical. Composite flours mostly have high protein, vitamins which can be scarcity in wheat content. At the present time in world cuisines have a lot of recipes using composite flours. Such as various forms noodles or pastas, cookies, bread, pastries, snack foods and etc. For example, soya bean or quinoa flours have great source of protein and nutrition and in some developing countries are considered as modern food. Composite flours are at the same time advantage to save foreign swap and induce to raise local agriculture and agribusiness.

2 LITERATURE REVIEW

Baking quality of bread depend from the flour. Nowadays, humans are using a lot of various types of flours and every year demand of flour or flour products increasing. Bread significant as a source of vitamins B and E, carbohydrates and protein (Pena *et al*., 2012). Bread is baked products from flour which during preparation for meal can mixed, fermented and moistened. It has huge number of various shape, component and recipe in worldwide. The first bread was cooked in Neolithic times, about 12000 years ago and in ancient Egyptians find out the method which can ferment the dough, thus forming gases, produced a light, expanded loaf, and they also developed baking ovens (Sinha *et al*., 2015). Population of world increasing every year and consumption of baking products increasing too. Trends of bread consumption in developing countries depends from some factors as: degree of government controls in wheat trading; extent of the variation from a more rural to a more urban population, which is the change of foodstuff habits and an upsurge in the precedence for processed, convenience foods; degree of adoption of foodstuff habits of developed countries and amount of upsurge of the revenue of the. This is mostly in China, Southeast Asia and in Middle Eastern countries. Bread consumption lower in sub-Saharan Africa individuals (Pena *et al*., 2012). Below Figure 1, demanding of bread production were higher in 2005 – 2006 years.

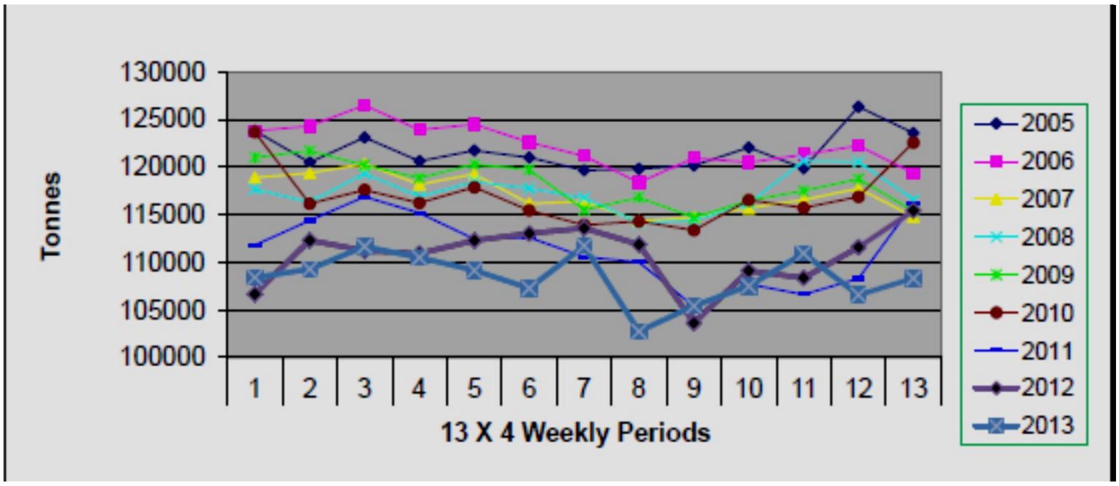

Figure 1. Total bread production

(Source**:** Nicholas P. 2012 – 2013. Bread production data. FOB. Available at http://www.nabim.org.uk/statistics/flour-and-bread-consumption)

2.1 Flour

Flour is a powder, which prepared from cereals either starch based produce. Flour is the general component in bread production and general component of baked food which forms a staple food in a lot of countries. Accordingly, the accessibility of sufficient source of flour has frequently been a main economic and political problem. Flour prepared from wheat grains is the greatest acceptable form for baked goods that need soft structure. Wheat seeds or kernels, are consist of the starchy endosperm, or food-storage port, make up approximately 85 percent; some external layers that constituting the bran, make up approximately 13 percent and the oily germ either embryo about 2 percent (Figure 2). Flour is produced from either from sole endosperm or endosperm combined with other parts of the kernel (Duignan , 2013).

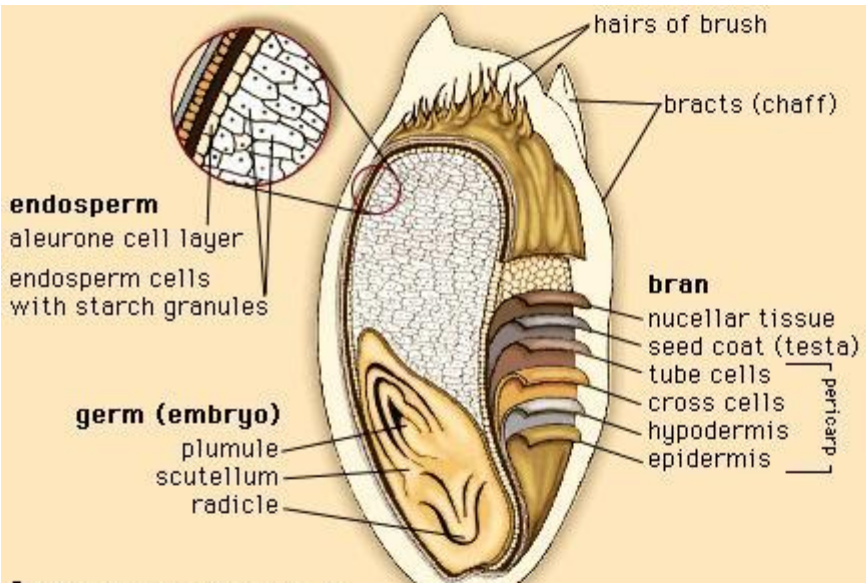

Figure 2. Wheat (*Triticum aestivum*): wheat kernel.

(Source: Duignan B, Chauhan Y, Abhinav VGY. 2013. Flour. Encyclopedia Britannica. Available at http: // [www.britannica.com/EBchecked/topic/210976/flour //](http://www.britannica.com/EBchecked/topic/210976/flour))

In milling of refined flours the wheat kernels are cleaned and moderated by the complement or disposal of moisture and then divided by a couple of rolls. The last stages, known as break flour, are riddled out and bagged. Larger units of endosperm (known as semolina) and parts of bran with endosperm affixed are then exposed to a parts of rolls in which semolina of constantly decreasing size is increasingly milled to flour and the bran divided out. The flour is frequently decolourized and preserved to get the better bread-making qualities before attained by natural mature. Flour results are created on the remaining quantity of branny units (Duignan, 2013).

When flour is mixed with water to prepare dough, its protein is transformed to gluten, an elastic material that forms a net through the dough and is able to saving gas, therefore affecting in the baked goods to increase. The toughness of the gluten depends from the protein consist of the flour. Soft wheat (*Triticum aestivum*), comprising about 8–12 percent protein, produce flours which are appropriate for foods demanding minimal structure, for instance: cakes, cookies (sweet biscuits), pie crusts, and crackers. Hard wheat (*Triticum durum*) has a high protein (about 12–15 percent) and produce flours that are appropriate for foods demanding stronger structure, for example pasta, breads, buns, hard rolls, and yeast-raised sweet rolls (Curley and Levy, 2010).

The text from German publication of Schunemann and Treu (1993) textbook was issued in 1986 by creation the technical demands of the West German educational program for learner bakers. The English publication was issued in 1988. Which corresponding, the techniques and terminology were improved to North American norms (Table 1). Extraction Rate is defined as the percentage of flour obtained from a given amount of grain.

The widespread variation of wheat (*Triticum aestivum*) flours usually accessible comprises full wheat (*Triticum aestivum*), or graham, flour, prepared from the whole wheat kernel, as well as frequently unbleached; gluten flour, a starch-free, high-protein, entire wheat flour. Multipurpose flour, refined (divided from bran and germ), bleached or unbleached and appropriate for any recipe not demanding a special flour. Cake flour, refined and bleached, with very reasonable consistency. Self-rising flour, refined and bleached, with supplementary leavening and salt. Enriched flour, refined and bleached, with additional nutrients (Brian Duignan *et al*., 2013).

Flour as well prepared from legumes [common bean *(Phaseolus vulgaris.),* chickpea (*Cicer arietinum*), broad bean (*Vicia faba)*, lentil *(Lens culinaris),* soya bean *(Glycine max*)] and nuts [almond *(Prunus dulcis),* hazelnut (*Corylus avellana),* cashew *(Anacardium occidentale)*, pistachio *(Pistacia vera),* Brazil nut (*Bertholletia excelsa*)], root and tubers, for instance: cassava, sweet potato *(Ipomoea batatas)* and another too. Flour which produced from non-wheat crops is else called as composite flour (Adeleke, Odedeji, 2010).

The Classification of flour is varied flour sorting schemes occur in North America and Europe. Table 1 is modified from a textbook by Schunemann and Treu (1993).

Table 1. Flour types and characteristics

	Hard Wheat Flours
Top Patent	0.35 - 0.40% ash content; 11.0-12.0% protein Uses: - Danishes, sweet dough's, yeast doughnuts and smaller volume breads and buns.
First Baker's	0.50 - 0.55%. ash content; 13.0-13.8% protein Uses: multipurpose strong baker's flour, breads, buns, soft rolls and puff pastry
First Clears	0.70 - 0.80% ash content; 15.5 - 17% protein Uses: A dark very high protein flour used as a base for rye bread production; poor colour not a factor in finished product.
Second Clears	Low grade flour, not used in food production. Constitutes less than 5% of flour produced by a mill.
	Soft Wheat Flour
Cake Flour	0.36-0.40% ash content; 7.8 - 8.5% protein, chlorinated to 4.5-5.0 pH. Uses: High-ratio cakes (cakes with a high amount of sugar and liquid in proportion to flour), angel food cakes and jelly rolls.
Pastry Flour	0.40-0.45% ash content/8.0-8.8% protein, chlorinated to 5.0-5.5 pH, (also available unchlorinated). Uses: Cake, pastries and pies.
Cookie Flour	0.45-0.50% ash content; 9.0 - 10.5% protein Uses: Cookies and blended flours. For large-scale manufacturers, flour can be chlorinated to the user's specifications.
Whole Wheat Flour	Various bran coat granulations produce coarse to fine whole-wheat
	Other Flours
Stone-Ground Flour	Usually untreated and, because of germ content, is subject to limited shelf life. (100% extraction).
Cracked Wheat/Rye	Available in coarse, medium or fine granulations
Semolina	Semolina A fine meal consisting of particles of coarsely-ground durum.

2.2 Composite flour

Composite flours are conjunction of wheat and non – wheat flours. Non – wheat flours can made from blends from cereals, legumes, roots, tubers, or from other raw materials. Composite flours from can from 5% to 50% or fully replace. The principle of composite flour technology was of mixing wheat flour with cereals and legumes or with other raw materials to produce great quality of food products.

2.2.1 History of composite flours

The advertising of composite flours in the production of baked products begun formally in 1964, after the Food and Agricultural Organization of the United Nations set off its Composite Flour Program. The aim was to find a novel substitution for wheat in bread making, baked foods and pasta products then to find flour preparations with compositions compounding top nutritious worth with suitable processing features (De Ruiter, 1978).

Until the 1960s, scientist did not have scientific interest in composite flours. In some countries at this moment wheat flour was expensive such as Papua New Guinea, African, Southeast Asian, South American countries. The first interest of composite flour technology had Pierre Chatelanat and the FAO. For publication they two causes of interest: firstly, starch chemistry and baking technology done probable the usage of mixtures and opportunity of gluten-free commodities for baking; secondly, there was a rise in interest into the nourishment difficulties of the anew developing countries of the tropics. Three intercontinental organizations were dynamic in the first period of composite flour study: the Tropical Products Institute (TPI, now the Natural Resources Institute [NRI], UK), Kansas State University (USA), and the Institute for Cereals, Flour and Bread (TNO) , Wageningen. They were the last institute which done the basic scientific finding that woken interest in the opportunities of composite flour. TNO explorers wrote that dough and bread composition can be shaped consuming starch with surface active agent as glycerol monostearate (GMS). It was detected that the crumb structure and capacity of bread enhanced by appending these surface active agents and that feebler wheat can be consumed considering retentive normal crumb structure and capacity. The Wageningen labor was afterwards transported to Colombia, where bread comprising 30% cassava starch was baked at the experimental measure. It was less positive. The Flour Milling and Bakery Research Association in Chorleywood, UK, developed a procedure in the early 1960 years by which flour with lower than common gluten comprise could be accustomed to create bread by mechanical dough development. Hulse *et al*., (1969) reported about "Mechanically Developed Doughs from Composite Flours" by Chorleywood process to make bread containing 30% non-wheat flour. The experiment was at TPI monitored from it research and the Institute has after been participation as NRI in composite flour from 1969 (Dendy *et al*., 1970; Crabtree and James, 1982). From 1972`s year, the first Composite

Flour Bibliography was issued by TPI, it comprised 160 quotes. Though factual consumer tests were sparse and were effective in Colombia, Kenya, Nigeria, Sri Lanka and Sudan. The quality of composite flour bread was more higher than local baker`s working with unpurified equipment, absence of procedure control and not good quality flour. Crabtree and James (1982) issued an article planning TPI's experiments in composite flour and offering 10 demands for realization of the composite flour program. TPI thinks about the custom of composite flour in bread preparing proposals possibility for favorable progresses in a lot of tropical countries nonetheless practice up to the present time has been off - putting, substantially as of the deficiency of infrastructure in the wording of composite flour programs. The composite flour technology has long since been vindicated (Dendy, 1992).

The next steps are needful to establish a program.

1. A technical research should be make a move to define the layer of non-wheat replacement that can be reached under local states. Because a lot of experience is already in work, its research can take weeks, not months.

2. An economic research is significant to appreciate the equilibrium among the economies on wheat importations and the investment wanted to the purchase of processing and mixing equipment if these are not accessible.

3. A certain decision should be taken by Government to continue with a national realization program monitored by a formulation of policy.

4. Accessibility of corresponding variations of the thinners seed should be guaranteed to ensure most favorable quality characteristics for the composite flour commodities.

5. Grain production and grain source volume should be guaranteed.

6. The program of improved production of the non-wheat diluent and the position of reasons to promote farmers to cultivate the product are of overriding meaning.

7. The choice and setting up of processing and mixing equipment must be make a move with owing affection for the needed partnership of the millers.

8. The teaching of bakers in the usage of composite flour in bread preparing is commended. It cannot be needed, nonetheless the bakers should be participatoin in considerations from the beginning of the program.

9. A market review on the admissibility of the composite flour bread and the formation of the consumers play major role. Customer organizations and the fourth estate should be gained on beginning in the program.

10. The formulation of quality norms for the seed and for the composite flour necessity to be determined.

About composite flour was published in 1985 by the UN Economic Commission for Africa (ECA) in the "Technical Compendium on Composite Flours" (1985). This book determined the technologies accessible for using: few of methods have been accessible from the beginning of 1970s. Technologies for making of flours, which TPI acknowledged in the beginning of 1970s as decisive, are given properly consideration, as are sorghum and the millets. This must be create in national grain policies, subject to bread consuming can be bounded to such markets demanding a convenience food. Potentially of much more important - national agriculture is the evolution of markets for innovative and enhanced commodities from sorghum and millets. The commodities with the suitability of bread composited and the conversion of tradition (Dendy, 1992).

Composite flour experiments were conducted in Brazil in which 75% wheat flour was blended with the attitude quantities of potato, maize or cassava flour. The baking tests were lead on the foundation of the Chorleywood bread process. The similar flours were utilized as row materials for pastries, nonetheless the part of wheat flour was diminished on 50% (Berghofer, 2000). Composite flours a can be member in programs to resisting from caeliac disease. In Africa – greatest of the tests with composite flour have been realize, for incessantly rising population. Records are accessible from Senegal, Niger and Sudan (Berghofer 2000). In the bread part the objective here was to produce characteristically to French bread with composite flour. The part of wheat flour in the dissimilar mixes various noticeable, the high appearing 70%. For the reason that of the hardship of saving bread fresh, a many tests were kept with composite flours in pastry productions (Jongh, 1961). Composite flours comprising wheat and another cereals and non-grain seeds have risen in popularity in the baking technology due to consumers' rising interest in wholesome food. In the past few decades, soybean or spelt have been effectively comprised in common bakery raw materials. Moreover, novel non-traditional components [e.g. amaranth (*Amaranthus albus)*, quinoa (*Chenopodium quinoa*), lupine (Lupinus albus), chickpea (*Cicer arietinum*), chia (*Salvia hispanica*), hemp (*Cannabis sativa*), teff (*Eragrostis tef*)] are getting high interest due to their frequentative characters in increasing the rheological properties of dough, general bread quality and nutritional worth (Hrušková *et al*., 2012). The composite flours based on wheat and others cereals and non-grain seeds have been famous in the baking technology.

In the most research aim was to identify the proportion of the substituted wheat flour and to search out mixes of flours which consistence mixes in an optimum method the nutritious worth with the satisfactory processing properties. Modern non-traditional components [e.g. sunflower (*Helianthus annuus*), amaranth (*Amaranthus albus*), quinoa (*Chenopodium quinoa*), lupine (*Lupinus albus*), chickpea (*Cicer arietinum*), flaxseed (*Linum usitatissimum),* chia (*Salvia hispanica*), hemp (*Cannabis sativa*), teff (*Eragrostis tef*)] show various characters in enrichment of the dough rheological properties and in rise of bread quality and nutritional worth (Best 2009; Ohr 2009; Mironeasa *et al*., 2011). Before study of composite flours were to retain the main possible percentage of wheat flour in the production of definite baked goods. The amount of wheat flour might be substituted with other vegetable flours naturally depended on the nature of the products to be baked. The usage of composite flours with or without wheat increased the technical problems in the production of baked products. The most significant element of wheat flour is the protein of the gluten which represents a crucial role in dough formation, gas retention and the composition of the crumb (Seibel, 2006).

2.2.2 Composite flours in developing world

We have a lot of various composite flours now. For example: wheat with sweet potatoes, wheat and cassava, wheat and many legumes, millet, and other composites. Custom of composite flour created on wheat and other cereals together with insignificant millets in bakery products is famous because of the economic and nutritional benefits (Dasappa *et al*., 2004). The composite flours comprising wheat and legumes are used in many country of the world. Numerous researches on the effect of the supplement of legume flours to the functional properties of bread dough and bread worth have been described in the last 30 years (Iyer and Singh, 1997).

From the high price, geographical shortage and high inquiry of wheat flour, striving have been focused to the submitting of other source of flour. For instance, Horsefall *et al*., (2007) informed, the composite bread can be prepared by replacing 5, 10, 15, 20 and 30% plantain flour for wheat flour. Cocoyam flour is a great additional for wheat flour in bread preparing (Essien, 2006). Idowu *et al*., (1996) reported that opportunity of consuming starchy affixes for bread preparing depends from the physical and chemical characteristics of the product (Eddy *et al*., 2007).

Most interest in the production of appropriate flours from locally and profusely developed raw materials in evolving countries have been reported. Faure (1971) stated that the potential of producing biscuits from combinations of wheat flour, corn flour and cassava starch in Uganda. Foods of well quality were prepared. Asserbergs (1970) correspondingly reported that biscuits can be a superior employ of composite flour than bread. At one time, earlier the prohibition on the import of wheat in Nigeria, biscuits were prepared solely from 100% wheat flour. Nigeria has adverse climatic environments for wheat cultivation nonetheless appropriate for other cereals, legumes and vegetables. Consequently, consuming of cereal based products as biscuits necessitate development of a satisfactory replacing for wheat. Dupaigne, Richard (1965) reported that ripe banana flour in wheat flour on the level of 24% in the manufacture of a lot of biscuits. Pigeon peas (*Cajanus cajans*) and millet (*Pennisetum glaucum*) have high sources of protein which are underuse in Nigeria. Pigeon peas have an interesting worth and high protein from economic point of view (FAO, 1983). Hard wheat flour with great gluten composition volume is not appropriate to pastry production. That`s why loss of capacity, shrinking and a hard pastry with bad external shape (Pawar and Parlikar, 1990). Soft wheat flour with composite flour is, thereby, favourite for production of well quality biscuits. The biscuit flour can be on the rough side quite than can be very well. The dough features define the shaping method working and appropriate not only a various form, nonetheless also a different consistency for cookies. Therefore, characteristics of the flour have a great effect on quality of the biscuits (Eneche, 1999).

2.2.3 Composite flours for bread purposes

Preparing bread by replacing portion of the wheat is not a modern or novel idea. Historically, the very often used thinner was barley and frequently bread comprising big numbers of barley was the staple food for people. In Britain barley *(Hordeum vulgare*), rye *(Secale cereale),* oats (*Avena sativa*) and occasionally beans were supplementary with wheat flour, which in a lot of years were to consuming by human. Bran was often used to complete wheat flour for the poor to gratify the market for white flour of the rich (Drummond and Wilbraham, 1957). On the end of the 19th century, Britain was importation big amounts of wheat from North America. They had big industrial population just as deficiency affected within the First World War, importation were diminished. However in last times of deficiency and need arose that complement non-wheat resources to bread. Barley, as cultivate well in Britain, was selected as the main thinner. Initially, barely 5% of the thinner was supplementary to the wheat, nonetheless the amount was little by little enlarged and in the end of the war, bread constantly comprised approximately 20% "adulterant" and up to 90% extraction ratio of wheat flour. The exciting term "adulteration" is also used by millers and bakers who deprecate composite flour programs. Within the Second World War had commixtures were also used and today, in temporary deficiency of imported wheat, local materials have been consumed as thinners in developing countries.

A lot of the researches before lead on the usage of composite flour for bread preparing goals (Dhingra and Jood, 2004) were reported to deciding the impact of biological source of flour and degree of wheat flour replacement on their bread preparing quality. The composite flours utilized were or binary either ternary mixes of flours from several other crops with or without wheat flour. They mainly experiential contraction in bread capacity and violation of sensorial qualities (external and internal characteristics) as the layer of replacement of wheat with non-wheat flour improved. Several types' variation of the similar plant in the case of bread preparing potential were published too. Defloor, Nys, and Delcour (1993, 1994, 1995) and Khalil *et al*., (2000) reported that experiments were presence of composite flour in wheat flour up to approximately 30% might also give a reasonable tasty bread dependent upon the basis of flour.

2.2.4 Recent usage of composite flours

In last years, breads and other pastry products have been produced which prepared from composite flours. These flours are beneficial to developing countries as wheat importation can be diminished and facilitate consume of the locally cultivated seeds (Hugo *et al*., 2003). Certainly, scientific investigation have been directed with the purpose of upgrading the consumption of composite flours, increased diminishing the market to imported wheat flour and improved bread consumption (Giami *et al*., 2004). Several of these investigation contain: Production of bread from composite flour of cassava and wheat flour (Shittu *et al*., 2006), Replacement of wheat flour with taro flour in bread preparing (Ammar *et al*., 2009); Replacement of pumpkin flour in wheat bread (See Ean Fang, 2008) and production of bread from tiger nut (*Cyperus esculentus*) - wheat composite flour (Ade-Omowaye *et al*., 2008). Every component will transfer distinctive colour, texture and nutritious worth which can be advantageous in bakery foods, recipes and other products. Sweet potato flour can be source of nutrients (carbohydrates, beta-carotene and vitamin A), minerals (Ca, P, Fe and K) and can supplement of natural sweetness, colour, flavour and dietary fiber to processed food products (Woolfe, 1992; Ulm, 1988). Therefore, the purpose of this experience with composite flours were to produce of wheat-sweet potato bread and to appreciate the nutritious constituent and sensorial qualities to define the admissible of the bread commodity (Ifie Idolo**,** 2011)**.**

Composite flour utilized for noodles as well. Pasta - the greatest quality was reached with mixture flours comprising of 60% cassava starch, 15% peanut flour and 25% wheat flour otherwise 30 % maize, 40% soy and 30% wheat (Seibel, 2007). Only there were experiments in which no wheat flour in general was utilize - only over 80% pre-gelatinized maize flour and 20 % soy flour. In Japan, noodles with or from buckwheat (*Fagopyrum esculentum*) are traditional meal, thus no one thinks there to prepare from composite flour (Seibel, 2007). Scientists have tests to utilize wheat (*Triticum aestivum)* with sweet potato (*Ipomoea batatas)* composite flour in the production of white, salted and yellow, alkaline noodles in staple noodle structures (Collado and Corke, 1996; Collado *et al*., 1997). Now in the actual study, they have concerning few records accessible on the nutritious worth of faster fried noodle goods prepared from a composite flour of wheat and sweet potato and no records are accessible on the antioxidant activity of sweet potato flour and noodle commodities (Kasetsart, 2009**)**.

The plantain flour production of baked commodities can decrease our complete dependence on imported wheat. It is significant research with plantain flour to define the quality of composite flour. The flour quality can be evaluated by physical and chemical tests in addition by baking tests. A lot of researches have worked the physical and baking qualities of differ starchy staple crops as cassava, cocoyam and taro (Horsfall, 2007). Idowu *et al*. (1996) researched the usage of cocoyam flour as complex with wheat flour in bread and pastry production; up to 10% and 80% replacement with cocoyam flour produced reasonable breads and pastry. Akubor (1998) has demonstrated that plantain flour has a well opportunity for usage as a functional agent in bakery commodities at the expense of its high water absorption volume, nonetheless rating of the functionality of flour in experiment baking has not been showed. Test obtained in the usage of composite flours has obviously showed that for causes of either commodity technology and consumer acknowledgement, wheat is a significant ingredient in a lot of flours. The percentage of wheat flour necessary to reach a definite influence to composite flours depends strongly on the property and amount of wheat gluten and the nature of the commodity participation. Nowadays the price of bread and biscuits is very high and thereby affords stimulus for farther study in the usage of composite flour for baking. Its research appreciated the nutritional-functional and baking properties of wheat with plantain composite flours.

2.3 Plant characteristics which used for composite flour

2.3.1 Wheat

Order: Poales (Glumiflorae)
Family: Poaceae (Gramineae)
Genus: *Triticum*
Species: *Triticum aestivum*

The archaeologists found that wheat from the southern Caspian zone about 5000 BC. In present time, bread wheat grown in every country of the Earth. Annual plant with spring and winter uniforms. Wheat is grown up to 150 cm tall grass, which has from 2 to 5 (40) tillers and culm is round, smooth. Leaves are alternate, plain and distichous and shell rounded, auricled and ligule membranous, blade linear from 15 to 40 cm, parallel, glabrous or pubescent. Inflorescence is terminal with distichous spike 4 – 18 cm long. Spikelet 10 – 15 mm long, sideways compacted with bisexual florets, 3 – 9 flowered. Fruit is caryopsis, in one part with a centric slot, colour of seed is from ruddy brown to yellow, white (Belay, 2006).

Crop can grow in near Arctic regions and the equator. Minimum temperatures for growing are 3 – 4 ^{0}C and maximum temperatures are 30 - 32^{0}C. Optimal temperatures for development of plant 10 - 24^{0}C and optimal an average temperature for yields 18^{0}C. From 35 ^{0}C the stoppage of photosynthesis and growth and after 40^{0}C the hot weather slays the plant. Crop cannot grow well in high moisture and under warm form. Wheat need rainfall from 250 - 750 mm during growing period. Soil requirement: need well aerated and well drained, pH between 5.5. Wheat is very sensitive to soil salinity (Heyene, 2012).

Bread wheat flour is prepared in amount commodities comprising bread (leavened or flat; baked, steamed or deep fried), pastries, crackers, biscuits, pretzels, noodles, farina, breakfast foods, baby foods and food thickeners. They also utilized as a preparing component in definite beverages (white beer). Sour breads are the very famous usage of wheat in the world. Improved bread consumption is frequently connected with rising urbanization and higher per head revenue. Bread wheat employment has also been useful to regional food. In Ethiopia, for example, the flour is used to cook ‘injera’ (slapjack-as fresh bread), porridge and soup. The seed is eaten as a appetizer in social meetings as ‘nifro’ (boiled full seed frequently mixure with pulses), ‘kollo’ (roasted seed) and ‘dabo-kollo’ (ground and seasoned dough, shaped and deep fried) (Brink M and Belay G, 2015).

Manufactural employ of wheat foods centre on the production of glues, alcohol, oil and gluten. Products of flour milling, especially the bran, are utilized as forage livestock, fowl or prawns. Wheat seed (from wheat embryos) used as a people food addition. Straw is fed to ruminants or used for bedding material, thatching, basketry, newsprint, carton, wadding material, fuel and as substrate for mushroom production. In dry areas of the world it is shredded and mixed with clay to make building material (Belay, 2006).

2.3.2 Hemp

Order: Rosales
Family: Cannabaceae
Genus: *Cannabis*
Species: *Cannabis sativa* L.

Hemp is native from temperate zone of Asia such as near Caspian Sea countries, southern Siberia and northern India. The oldest non – food plant and it was valuable as fibre product by Chinese people 8500 years ago. Nowadays hemp is grown in worldwide (Jansen *et al*., 2006).

Annual herb, commonly erect; stems volatile, up to 5 m tall, with pitchy pubescence, angular, occasionally cored, particularly above the first pairs of true leaves; basal leaves opposite, the upper leaves alternate, stipulate, long petiolate, palmate, with 3-11, rare single, lanceolate, serrate, acuminate leaflets up to 10 cm long, 1.5 cm wide; flowers monoecious or dioecious, the male in axillary and terminal panicles, apetalous, with 5 yellowish petals and 5 poricidal stamens; the female flowers germinate in the axils and terminally, with one 1-ovulate ovary; fruit is brown, shining achene, diversely noticeable or simple, densely ambient the grain with its thick endosperm and bent embryo. Grains weight 1.5-2.5 gm/100 seeds (Duke, 1983).

A reusable plant, furnishing fiber, oil, medicine and narcotics. Fibers are the greatest produced from male plants. In the temperate area, oil is produced from females which have been left to stand after the fiber-producing males have been harvested. Leaves are prepared to soups in Southeast Asia. Lacquer is component from the pushed seeds. Three forms of drugs are produced: hashish (bhang), the desiccated leaves and flowers of male and female shoots; ganja, desiccated unfertilized inflorescences of particular female plants; and charas, the crude resin, which is likely the strongest. Newly medicine usages cannabis in glaucoma and alleviating the tablets of cancer and chemotherapy. Most resin is made in tropical than in temperate climates. Lewis lung adenocarcinoma growth has been defective by oral management of delta-9-tetrahydrocannabinol, delta-8-tetrahydrocannabinol and cannabinol, nonetheless not by cannabidiol. The delta-9 as well suppress the response of Herpes simplex virus. (Duke, 1983).

2.3.3 Soybean

Order: Fabales
Family: Fabaceae
Genus: *Glycine*
Species: *Glycine max* L.

First publication about soybean was from China that they cultivated in northeast part and used as food stuff near the 11th century BC. In present time soybean is extensively grown in subtropical, tropical and temperate zones of worldwide (Giller and Dashiell, 2007).

Soybean is erect, annual herb which up to 2 m or sometimes viny. Crop have branched taproot - 2m long. Stem is brownish or greyish pubescence. Leave is alternate, trifoliolate or sevenfoliolate; stipules widely oval (3 – 7 mm); petiole from 2 to 20 cm long and leaflets oval to lanceolate. Inflorescence an axillary false (3.5 cm) and mostly compact, densely hairy. During blooming flowered from 2 to 35. Flowers are bisexual and have white, pink, purple or bluish colour. Fruit is pod with hairy, little bit bent, dehiscent. In pod from 2 to 5 seeds, seeds are rounded to oval or rhomboid shape and yellow, green, brown or black, blotched and mottled in conjunctions of those colours (Giller and Dashiell, 2007).

Soybean has multi-uses. This mostly squeezer to extraction soybean oil, later on a soybean food leavings, such as a rich source of protein. Soybean oil can be utilized for the production of eatable oil such as kitchen oil, salad oil and another over cleaning and hard processing. Soybean oil can utilized for the production of conjunction feed. This is the general protein source in feed for livestock farming. In manufactural production used as ornamenting materials, printing toners and as pesticides. Crops oil is the major mercantile source of α-tocopherol (natural vitamin E) and comprises stigmasterol, which is used for the commercial synthesis of steroid hormones and other pharmaceutical products (Giller and Dashiell, 2007). The local soybean food produced on low temperature states is mostly utilized for the production of insulated soy protein, focused protein and structural protein. These proteins are supplemented to different foods in the meal – treatment industry for the production of soybean protein – rich foods. For example, wheat flour added with a definite quantity of soybean protein for the production of bread and cake. Soybean protein complement better the water absorption of meat and the palatableness of sausages. Soybean protein can be utilized to operation protein fiber, which can be mixed with cotton, wool or chemical fibers. The structure of the effecting fabric is mild and high quality (Guriqbal Singh, 2010).

2.3.4 Quinoa

Order: Caryophyllales
Family: Amaranthaceae
Genus: *Chenopodium*
Species: *Chenopodium quinoa* L.

Quinoa is a native for Andean region and was important for Incas peoples about 5000 years. Incas peoples call this plant such as “the mother grain” (Lilian, 2009).

Quinoa is annual crop with a vertical stem and stands alternate leaves that are different coloured owing to the attendance of betacyanins. A good cultivated, very branchy taproot system is represent, pervasive as deep as 1.5 m under the surface, which resistance from drought weather. Crop mostly grown in high elevation, around 4000 m above sea level (Karyotis *et al*., 2003). Quinoa is a starchy dicotyledonous seed, because of dicotyledonous seed this is not a cereal, so it is a pseudocereal (Wright *et al*., 2002).The leaves show polymorphism; the upper leaves being lanceolate whereas the beneath leaves are rhomboidal. The inflorescence is a panicle, 15–70 cm in length and raise from the upper of the plant and in the axils of lesser leaves. A significant characteristic of quinoa is the attendance of hermaphrodite and unisexual female flowers. The hermaphrodite flowers are situated at the distal and have five perianth lobes, five anthers and a greater ovary with two or three stigmatic branches (Bhargava *et al*., 2005). The fruit is an achene, inclusive some levels, perigonium, pericarp and episperm , from outside to inside and can be conical, cylindrical or ellipsoidal with saponins focused in the pericarp. Grain proportions and colour are different which black is commanding on red and yellow, which in change are dominant to white seed colour. Seed has high quality and high nutritional value (Ranhotra *et al*., 1993) and has as well high source of iron, magnesium, copper, phosphorus and vitamin E, little bit amount of B vitamins, potassium, and zinc (Lilian, 2009).

Quinoa is highly nutritious and is utilized to prepare flour, soup, mealtime and spirits. This is traded or as all grain that is baked as rice or in conjunction meals. It should fermented to prepare beer or used to feed livestock (Galwey, 1989). Full crops is as well used as green silage to fodder cattle, pigs and poultry. In Peru and Bolivia usage quinoa shavings, tortillas, pancakes and swollen seeds are produced commercially (Popenoe *et al*., 1989). Quinoa can deliberated as a prospective plant for National Aeronautics and Space Administration's Controlled Ecological Life Support System (CELSS), as purposes were to use crops for disposal carbon dioxide from the atmosphere and production of meal, oxygen and hydrogen for the group of durable area jobs (Schlick and Bubenheim, 1996). Therefore, quinoa might be efficaciously used in the potable industry to training of malted drink conceptualizations. Different researches demonstrated that magnification into the layer of IGF-1 (insulin-like growth factor-1). IGF in the plasma of children which used a additional part of a baby food efficient by drum drying a before cooked slurry of quinoa flour (Ruales *et al*., 2002).

2.4 Flour of samples

2.4.1 Wheat flour

Wheat is the greatest meal produce among plants. This is a main food of huge section of global populace. Wheat is everywhere utilized for production of flatbreads (Shewry and Tatham, 1994) .Wheat flour is the very famous and multipurpose flour and a huge number of sorts: white flour, differently called such as simple flour, comprises approximately 75 %

of the wheat from majority of the offal and wheat seed removed. Usually utilized for cakes, pastries and biscuits. All meal or all wheat flour is prepare from the full wheat seed. Full food flour produces hardier effects wherewith white flour like is frequently utilized in conjunction (Wright, 2010.).

2.4.2 Hemp flour

Hemp (sometimes known as marijuana) is herb which historically, cultivated for a lot of another causes. Hemp flour consist (20–30% proteins, 7–13% fat, most wherewith 40% saccharides) is a premise for this custom in untraditional cereal goods. Fit hemp have proteins which submitted mainly by edestin, a low-molecular globulin, technological action of composite flours compounds comprising from 5 to 20% of hemp flour is fundamentally dissimilar and from 5 to 15% composite hemp flour had good source of protein but 20% composite hemp flour was the highest (Švec and Hrušková, 2013-2015). Hemp flour is normally gluten-free, acceptable to the celiatics. Hemp can comprises a great source of beta-carotene and vitamins B1 and E. Hemp have good source of a mineral comprise and big source of iron and zinc (Hrušková *et al*., 2012). Hemp flour has higher amylolytic activity than in wheat flour. Švec and Hrušková (2014) by comprising and estimating amylolytic activity of composite hemp flour from 5% to 20%, wheat flour was lower. Hemp flour has contain oil because in seeds a comprise oil and from hemp seed is produced the oil. Approximately 30% of hemp flour consistency is oil. If hemp flour composite comprising with differ flours, it comes to tasting as nuts, cool fragrance and a great amount nutritious (Leson, 2006). Appending the flour to wheat, barley, soy either another flours in a relation of unique portion hemp flour to four fragments from other flour different the structure, outcome of a heavier, chewier bread. Appending for baked commodities as bread, muffins, waffles and the as gives a good portion of fiber (Lachenmeier and Walch, 2005). Present larger of omega natural fatty acids and magnifications the digestible protein to additionally. Hemp flour as well attempt antioxidants, calcium, magnesium and different wholesome foods as zinc and manganese. A little amount increase hemp bread volumes. Similarly to that, composite hemp buns crumb texture as well changed - pores density increased and size softly decreased (Švec and Hruškova, 2013.). Peoples which do not have food allergies that have been united in hemp. It indicates that this is good for people which do not like impatient to different foods (Gregory, 2010).

2.4.3 Soybean flour

Soybean flour contain good source of protein, rare wherewith different protein additions, can conduct to a more reasonable commodity or bread or ablactating meal, some evolving countries still cultivate soybeans in valuable amounts and some procedure the beans to a reasonable quality flour (Shurtleff and Aoyagi, 2004). Soy bean have two forms of soy flour: the unpurified soy flour as the usual enzymatic system has not been deactivated and the toasted soy flour as the enzymatic system has been ruined to better the nutritious worth (Berk, 1992). Every forms can be produced as or all fat either fatless flour. Distinguish betwixt two forms of doughs as soy flours can be utilized: leavened doughs and sweetened doughs (Dendy, 1974). Composite soybean flour had higher protein, ash then in wheat flour and supplementation wheat flour with soybean flour would greatly improve protein quantity of bread (Olaoye *et al*., 2006). Ndife *et al*., (2011) reported that by comprising whole wheat flour with composite soybean flours from 10 to 40%, wheat flour was the lowest in ash content than composite soya bean flour. One of the causes which the use of high protein flours in the fight on undernourishment is more bounded to random reasons should be that inadequate methods have been detected to work these flours in commonly received commodities). From this case, Food and Agriculture Organization developed a Composite Flours Program to promote the use of non-wheat flours in the production of bread, pastries and pasta goods (Berk, 1992). Ribotta *et al.,* (2005) reported that only soybean flour mixtures with wheat flour containing denatured proteins were able to form gluten. Meals terms as non-wheat flours are superior keepers for protein enhancement, for the reason that of food centralized production and the easement of mixing protein concentrates in the production. Other reason is obstructive the consumption of non-wheat flours in the production of bread and another baking products is expensive, upper than that of common wheat flour (Shurtleff and Aoyagi, 2004).

2.4.4 Quinoa flour

Quinoa flour is prepared by milling quinoa grains to a quality texture. Quinoa flour as multipurpose wheat flour without any problem can replace without in some baking recipes. Quinoa flour can as well be supplemented direct to soups and pot roast as a thickeners or utilized as a protein powder in cocktails. Bakers have interest in quinoa flour for gluten free baking, because bakers can include to their diets or prepare baked meals which has high protein and low carbohydrates. Quinoa flour has normally nutty taste and a trifle sweet flavour, attractions to everybody who interested in delectable baked foods. Gluten - free quinoa baking demands some of creativity and many replacements. Everybody can prepare quinoa flour in home (Saulsbury, 2012**)**. Quinoa has nutrient-rich seed which is a great source of protein, procuring entirely of the natural amino acids, enzyme activity. In Falling number increase the amount of quinoa flour will produce a rise in Falling number values. The decrease in 5 % and 10 % composite quinoa flour may be the result of delusion effect. Quinoa flour has higher enzyme activity than wheat flour (Enriquez *et al*., 2003). Its strong tiny seed which can be an excellently complement to most diet, however is a perfect decision for persons with vegetarian diet. You can replace or mix quinoa flour as partly or fully with another flour. You can us this flour as multi-purpose flour in most recipes or totally substitute wheat flour in cakes and cookie recipes. Quinoa flour prepared can prepare well with fruits, nuts and spices such as cinnamon, cardamom, cumin and coriander, as well as herbs like rosemary.

The grain flour has greater gelation characteristic, water-absorption volume, suspension capacity and constancy (Oshodi *et al*., 1999). Enriquez *et al*. (2003) reported that composite quinoa 5 – 10% does not influence to specific loaf volume. However composite quinoa flour 15% has high amylase activity, which increased in gas production and volume of loaf was higher. Measureable investigation of quinoa flour and this compare with differ cereals has demonstrated that quinoa flour generated free sugars as glucose (4.55%), fructose (2.41%) and sucrose (2.39%) (Gonzalez *et al*., 1989). Ogungbenle (2003) appreciated the sugar comprise and chemical structure of grain flour of quinoa and has greatest content of d-xylose (120 mg/100 g) and maltose (101 mg/100 g) a lower comprise of glucose (19 mg/100 g) and fructose (19.6 mg/100 g).

2.5 Rheological methods of flours

Rheology is science about deformation and flow of various materials. Rheological methods are typically classified according to the type of deformation such as compression, extension, shear and torsion etc. The basic purposes of rheological dimensions are:

1. To get a numerical specification of the materials mechanical characteristics;
2. To get data connected to the molecular texture and arrangement of material;
3. To describe and pretend the materials productivity throughout experiment and for quality monitoring.

Rheological procedures used for evaluating cereal properties have been shared in expositive empirical technique and fundamental measurements. With the cereals production there have been a long time history of consuming expositive empirical measurements of rheological properties, with an effective range of inventive instruments such as the Penetrometer, Texturometer, Consistometer, Amylograph, Farinograph, Mixograph, Extensograph numerous flow viscometers and fermentation noting appliances. Products measured by some rheological methods such as from Empirical methods – mixers: Farinograph, Mixograph, Reomixer; Extensograph; Taxt 2\Kieffer Rig; Alveograph; Amylograph (B.J. Dobraszczyk, M.P. Morgenstern,2003). For physical analysis of wheat flour doughs in 1930`s invented equipment, which known as Brabender Farinograph. Farinograph test is determined functionalization in preparation to evaluation value of water required to make a dough, to estimate mixing properties, requirements and to evaluate flour consistency. Fenn *et al*., (2010) wrote that mixing soybean flour with wheat flour increased Farinograph water absorption and increased protein contents. Water absorption of composite soybean 5% and 8% had from 66% to 69%, wheat flour had 63 %. Farinograph establishes the flour action during baking test. It submits the elasticity and plasticity of dough during mixing on invariable temperature. Good quality flour will have degree of softening between 30 and 50BU and stability value will not lower 7 minutes. Stability of wheat flour (10 min) was higher than in composite quinoa 5%, 10% and 15% (9 min, 8 min and 7 min) (Enriquez *et al*., 2003). Brabender Farinograph was accompanied by familiar apparatuses such as the National Mixograph, the Brabender Extensograph and the Chopin Alveograph. For Extensograph apparatus, dough is exposed to a conjunction of shift and specifically in the last phases, mostly uniaxial expansion. Its apparatuses have vindicated to be utility in practice technical additions and proceed to be utilized in investigation on wheat flour doughs (Janssen et al., 1996). Extensograph test has resting time from 45, 90 and 135 min. In resting time changed on extensibility and soybean concentration were varied. This parameter increased with the addition of 1.0 or 1.5% of composite soybean to wheat flour at 45 resting times. Resting time increases such as 90, 135 minutes, the extensibility values of soybean flours not affected as compared with wheat flour (Rosals – Juares, 2007).

3 AIM OF THE THESIS

Main aim:

Find composite flour of properties comparable to wheat flour with added values such as balanced nutritional composition and/or proper rheological properties.

Specific aim:

Analyze a range of the composite flours using the standard methods: protein, ash, gluten, falling number, rheological tests, baking test.

3.1 Hypothesis

1. Baking made from composite flours will have meaningfully refined or improved nutritious worth and have better source of protein, gluten, amino acids and minerals than in wheat flour;
2. In the analyze a range of composite flour of hemp and wheat will have influence to quality of bread;
3. Baking quality of dough will measure by rheological methods such as Extensograph and Farinograph. Composite flours plasticity and mobility will be significantly better than another samples, but gluten strength, extensibility and resistance to extension of wheat flour dough`s can be better.
4. Enzyme activity of falling number test affects to dough or baking quality. Enzyme activity will have lower amount in wheat flour than in composite hemp flour.

4 METHODOLOGY

4.1 Preparation of composite flour

The experiments were carried out laboratory of cereals quality in Czech University of Life Science in Prague. In materials for composite flour used 4 type of flours. It is wheat, hemp, soya bean, and quinoa purchased from following producers or sellers:

wheat flour	Lidl Česká republika v.o.s. **(**brand called Castello)
hemp flour	Mouky.cz - Netrea cz, s.r.o.
soybean flour	Paleta s.r.o.
quinoa flour	ASO Zdravý život s.r.o.

Flours have been prepared seven samples which mixed by mixing machine (Figure 3). Mixing have been for 10 % of composition 250 g replaced flour to 2250 g wheat flour and for 5% of composition 125 g replaced flour, 2250 g wheat flour.

Table 2. Type of sample and replaced percentage of composite flours

	Samples	Replaced percentages
I	Wheat flour	100%
II	Wheat + Hemp flour 5%	95 % + 5%
III	Wheat + Hemp flour 10 %	90% +10%
IV	Wheat + Soya bean flour 5%	95 % + 5%
V	Wheat + Soya bean flour 10%	90% +10%
VI	Wheat + Quinoa flour 5%	95 % + 5%
VII	Wheat + Quinoa flour 10%	90% +10%

The first sample is wheat flour, second sample are 5% hemp and 95% wheat flour, third sample are 10% hemp and 90% wheat flours, fourth sample are soya bean 5% and 95% wheat flours, fifth sample 10% soya bean and 90% wheat flours, sixth sample are 5% quinoa and 95% wheat flours, seventh samples are 10% quinoa and 90% wheat flours (Table 2).

 

Figure 3. Mixing machine

4.2 Rheological methods of composite flour

Rheological method can show the physical characteristics of the composite dough and flours. This methods connected with several parameters of composite flour`s dough such as water absorption, dough development time, dough stability, resistance and extensibility. Most test worked with apparatus which called – Farinograph and Extensograph machine.

4.2.1 Farinograph test

The principle of Farinograph measures and writes the consistency of the dough during its production from flour and water, during its evolution and re-kneading. The maximum dough consistency is adjusted to a fixed amount of added water. Proper addition of water, which is called as water absorption used to obtain full curve of kneading, which various shapes are indicators of the strength flour.

Materials:

Determination water absorption and of rheological properties on the Farinograph test was prepared by ISO 5530-1, ČSN 56 0114.

Apparatus: Farinograph (Figure 1) with thermostat (unit with 300 g kneading machine or device Egger is 100 g kneading machine), burette, scales to weigh ± 0,1g , plastic spatula; 300 g of composite flour, distilled water, and table salt (NaCI).

Methods:

Farinograph kneading machine is moistened with a drop of water between the back wall and each blade. The amount of flour corresponding to 300 g of flour is weighed with accuracy of 0,1g. The flour is placed in a kneading machine which was close. Flour was stirred at a given rotation speed 1 minute or longer. When the pen moves across the line of whole minute, water starts to be added from a burette into the right front corner of the kneading machine. It added as much water as expected to achieve maximum consistency of 500 FJ. When the dough is created, attached pieces from the sides of container are scraped by a spatula and added to the dough. If the consistency is too high, water is added to obtain the maximum consistency of approximately 500 FJ. When the moves to upside, kneading should be stopped, cleaned. After adding water should write finally percentages or milliliters of added water. Farinograph water binding capacity, expressed in ml per 100 g of flour with a water content of 14%, the result is given to one decimal place. From kneading machine have been prepared dough and graphs. Graphs showed physical characteristics such as water absorption, dough developing time, dough stability, and degree of softening of composite flour. The dough developing time is the time from the beginning of water addition until the moment when the first hint of consistency falling is reflected and the measured by minutes. The degree of softening is the difference in height of the curve between the center of the curve at the end of generation of the dough and the center of the curve 12 min after this point. Dough stability is the time in minutes when Farinograph curve intersects (for the first time and last time) the value of 500 FJ.

4.2.2 Extensograph test

Principle is dough prepared under standard conditions from flour, water and salt on Farinograph. The test piece of dough is formed on roller and sheeters of the Extensograph into a standard shape. After expiration of fixed time, the test piece of dough is stratched and the required force (for stretching) is recorded. Immediately after the first stretching the two other stretches are done with the same piece of dough with re-shaping, re-laying (we are leaving the dough for a while to „lie“, to take a rest) and re-stretching.

Materials:

Determining the rheological properties on the Extensograph (Figure 4) test was prepared by ISO 5530-2, ČSN 56 0114. Apparatus: Extensograph with thermostat, Farinograph with thermostat, burette, scales to weigh ± 0,1g, plastic spatula, 250 ml conical flask; 300 g of composite flour, distilled water, sodium chloride solution.

Methods:

Kneading machine is moistened with a drop of water between the back wall and each blade. The amount of flour corresponding to 300 g (100g) of flour at 14% is weighed with accuracy of 0,1g. The flour is placed in a kneading machine which we will close. Flour was stirred at a given rotation speed 1 minute or longer. When the pen moves across the line of whole minute, sodium chloride solution is added into the right front corner of the kneading machine. From the burette is added the amount of water which is expected to achieve maximum consistency of 500 EU. When the dough is created, attached pieces from the sides of container are scraped by a spatula and added to the dough. If the consistency is too high, water is added to obtain the maximum consistency of approximately 500 EU. Kneading is stopped and kneading machine must cleaned up.

Pedestal with two tubes is taken out from the chamber, clamps are taken off. The dough is taken out from kneading machine. Trial piece of dough is weight out (150 ± 0,5 g). Its placed into the roller and the desk is rotated 20x. Its taken out from roller and subsequently it goes through sheeters. This placed into the middle of the tube and fasten by clamps. Second piece is weight out and formed in the same way. Time meter is set up at 45 min. Kneading machine is cleaned. Exactly 45 min after fastening of the first testing piece of dough, the tube is placed on the arm of balance and the stretchy hook is activated and lowered immediately. After dough breaking into two pieces, the tube is taken out, dough is formed, and the process of rolling and shaping is repeated. Time meter is set up at 45 min. Exactly 90 minutes after fastening of the first testing piece of dough, the tube is placed on the arm of balance and the stretchy hook is activated and lowered immediately. After dough breaking, the tube is taken out, dough is formed, and the process of rolling and shaping is repeated. Time meter is set up at 45 min. Exactly 90 minutes after fastening of the first testing piece of dough, the tube is placed on the arm of balance and the stretchy hook is lowered immediately. After dough breaking, the tube is taken out. Exactly 135 minutes, fastening of the first testing piece of dough, the tube is placed on the arm of balance and the stretchy hook is lowered immediately. After dough breaking, the tube is taken out. When hook is going down and up will break up the dough, Extensograph machine will write on registration paper. Distance written (expressed) on the registration paper is ductility from the moment when the hook touches the piece of dough until its breakup. The result is expressed with the accuracy of 1 mm. From graphs which were write on registration paper have been determined some characteristics of dough as resistance, extensibility and energy of dough. Maximum resistance for the stretching is maximum high of curve of Extensograph. The result is expressed with the accuracy of 5 EU (Extensographic Brabender units).

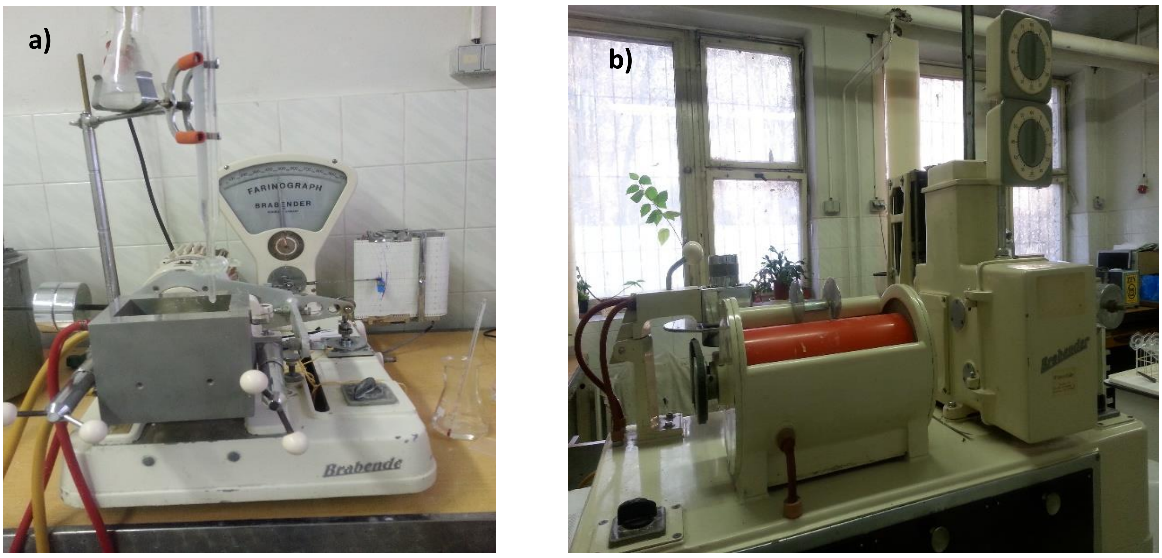

Figure 4. Rheological methods equipment: a) Farinograph; b) Extensograph

4.3 Materials for analytical analyzes of composite flour

From analytical analyzes can determine quality and quantity of protein, moisture, ash, gluten and enzyme activity of composite flour. Analytical analyzes are combination of test such as ash test, falling number, gluten test, moisture test and protein test.

4.3.1 Ash test

Ash is the amount of minerals that remains after burning of test sample under conditions of the method. Principle is the test sample is burned at a temperature of 900 ± 50 ° C and the not burned residue is weighed.

Materials:

Electric muffle furnace (oven) with automatic temperature control; Analytical balance capable of weighing ± 0.0001 g; Porcelain dish, desiccator filled with efficient drying agent**.**

Methods:

Into the pre-calcined (pre-annealed) and weighed porcelain dish (with accuracy of 0.0001 g), is weigh out (with the same accuracy) about 5 g of well mixed laboratory sample. The dish is placed in a muffle furnace that is preheated to 900 °C where it becomes carefully carbonized in the way that it is left afire freely with a weak flame (Figure 5). After flame extinction and smoke finishing, the furnace is closed and the sample is combusted for 180 min from the moment when the temperature again reaches 900 ° C. After this time the bowl is placed in a desiccator, and after cooling to the level of room temperature (the bowl) is weighed with the accuracy 0.001 g. The result is the arithmetic mean of the values obtained from two determinations, under the prerequisite, that the conditions of repeatability were fulfilled.

Calculation and results expression:

Content of ash (%) in dry matter is calculated according to the following formula:

$$w_0 = \frac{100 \text{ x } m_1}{m_0} \text{ x } \frac{100}{100-w_1}$$

Where,

m_0 is the initial weight for burning (about 5 g)
m_1 is the mass of the sample after burning
w_1 is moisture of the sample

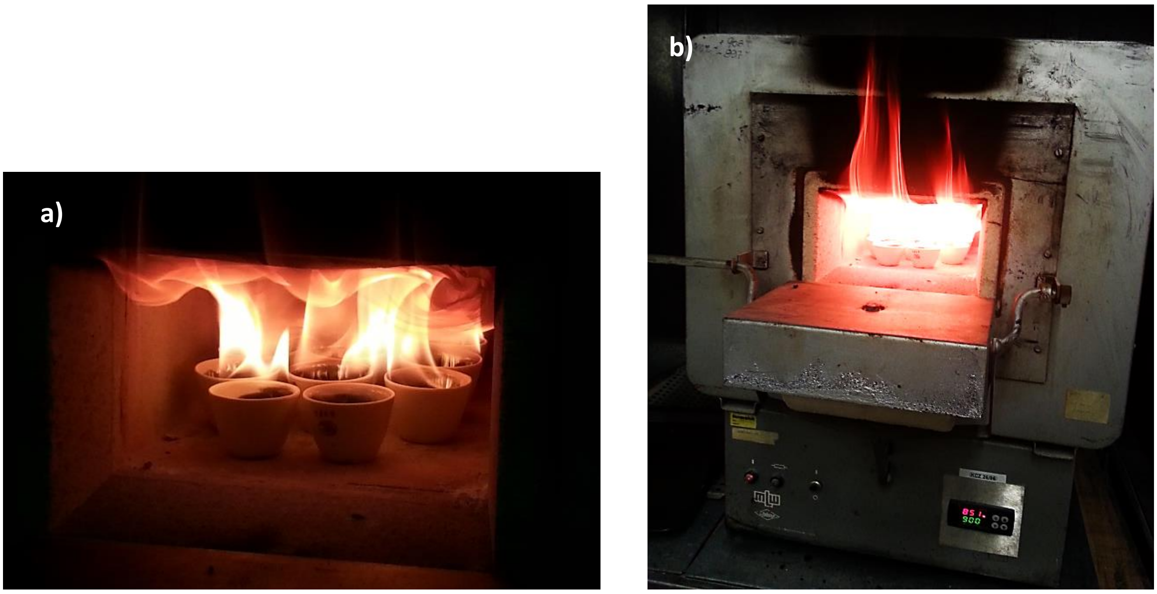

Figure 5. Determination of ash. (a) Porcelain dish with composite flour which carbonized by flame; b) muffle furnace).

4.3.2 Falling number

Falling number is the total time in seconds, from immersing of viscometric tube into hot water, including the time that is required for stirring by viscosimetric stirrer in specified way and furthermore the time that is needed for falling of the stirrer by the determined distance in aqueous gel prepared from flour that is included in the viscosimetric tube and in which takes place a liquefaction. Principle is rapid conversion to a sticky mass of aqueous suspension of flour in a boiling water bath and subsequent liquefaction of starch by an alpha-amylase contained in the samples.

Materials:

Chemicals: Distilled water or water of at least equal purity

Apparatus: Analytical balance (scale) with accuracy of weighing ± 0.001 g; Laboratory grinder; Falling number device (Figure 6)consisting of a water bath, electric cookers and automatic counters; Viscometric tube; Metal viscometric stirrer consisting of rod with a ring at the lower end of the rod; rubber stopper (plug) of viscometric tube; pipette 25ml ± 0,2ml.

Figure 6. Falling number device

Methods:

The water bath was filled with distilled water 2 to 3 cm below the upper edge of the container (vessel). The water is brought to the boiling point and throughout the whole process is maintained at 100°C. Test samples (amount indicated in the second column in the Table 3) is transferred to viscometric tube by pippete is added 25 ml of distilled water at 20 ° C ± 5 ° C.

The tube is immediately stoppered with a rubber stopper and vigorously shaken 20 times or more times in the hand to obtain a homogeneous suspension. The stopper is removed and into the tube is inserted stirrer that wipes down to the suspension particles of flour or milled product adhering to the walls of the tube. The tube with the stirrer is inserted into the holder in the water bath and the automatic counter will switch on. Precisely 5 seconds after insertion of viscosimetric tube into the water bath begins stirring of the suspension at a rate of one movement upward and one movement downward per second. After 59 seconds, the stirrer is stopped in an upper position, and exactly in 60 seconds after switching the automatic counter on, the stirrer is released. The counter stops automatically when the stirrer, which falls down due to his own weight, reaches the level of the top of ebonite plug and a sound will play. On the automatic counter the total time in seconds is subtracted. The result is the arithmetic mean of the values obtained from two determinations (under the prerequisite that the conditions of repeatability were fulfilled). The difference between the values obtained from the two determinations shall not be greater than 10% of their average value (Table 6).

4.3.3 Gluten test

Gluten in flour is plastic-elastic material, consisting of gliadin and glutenin, obtained by a specific method. Principal is preparation of dough from flour sample and NaCl solution. Isolation of wet gluten from the dough by washing (scrubbing), followed by removing excess washing solution and weighing of the residue. Operating procedure was by gluten “washer”- Glutomatic (Figure 7) or by hand.

Materials:

Chemicals: distilled water; sodium chloride of 2% solution

Apparatus**:** porcelain mortar and spatula**;** balance capable of weighing ± 0.01 g; wooden frame of size 30 x 40 cm coated (covered) with a sieve with holes about 0.315 mm ;automatic dispenser of 10 ml of volume, divided on 0.1 ml sections or a pipette; gluten „washer“ – Glutomatic (Figure 7a).

Figure 7. Gluten test: a) Gluten “washer” – Glutematic; b) Sodium chloride of 2% solution

Methodology for mechanical scrubbing:

With an accuracy of 0.01 g, 10.00 grams of the test sample is weighed and transferred quantitatively to a washing container with a fine sieve. From dispenser is drop by drop added 5 ml of NaCl (Figure 7b). After addition of sodium chloride, washing container is placed into gluten washer and the program starts. After dough preparation and subsequent automatic gluten scrubbing by using sodium chloride, the ball of scrubbed gluten is removed. The scrubbing solution adhered at the gluten ball is removed by centrifugation. Centrifuge includes two cartridges with a sieve, into which is inserted washed gluten. The centrifuged gluten is weighed with an accuracy of 0.01 g. It is weighed a portion that is adhered on the sieve and total gluten. Both values are used to calculate Gluten Index (GI), which characterizes the quality of gluten.

Calculation and expressions:

Gluten content (% of dry matter) is calculated according to the formula:

$$\frac{\text{weight of gluten adhering in the sieve (strainer) x 100}}{\text{total weight of gluten}}$$

Gluten Index value is calculated according to the formula:

$$\frac{\text{weight of gluten x 10 x 100}}{\text{dry matter}}$$

The result is the arithmetic mean of the values obtained from two determinations, under the prerequisite, that the conditions of repeatability was fulfilled.

The result is given to two decimal places.

4.3.4 Moisture test

This process defines moisture and flours are volatile under conditions of experience. Principle is weighed amount of test sample is dried in an electric oven at 130 ° C for 120 min (flour 90 min) and the rest is weighed after drying.

Apparatus: Analytical balance capable of weighing ± 0.001 g

Metal Drier that does not corrode under the test conditions (during the conditions of test), with a tightly fitting lid; thermostatic drying room (oven), electrically heated and regulated to ensure air temperature 130 ° C ± 3 ° C during the drying process; Desiccator containing an effective desiccant.

Methods:

To the pre-dried and with accuracy of 0,001 g weighed a dry container with a lid which is weight with the same precision, is weighed about 5 g of the thoroughly mixed laboratory sample that is spread into a uniform layer on the bottom of the dish. Dish with deflected lid (lid up) is placed to the oven that is preheated to 130 ° C and kept in an oven exactly 120 minutes (90 min) from the time when the temperature again reaches 130 ° C. After this time, in the drying room (in the oven) dish is covered by lid, placed into the desiccator, and after cooling to the room temperature, is weighed with accuracy of 0.001 g. Moister test have been calculated by these fallowing formulas. Each samples results must be different, from this formulas can determined moisture content and dry matter content in percentage of composite flour.

Calculation of moisture content (%):

$$\frac{(\text{weight before drying - weight after drying}) * 100}{\text{the portion}}$$

4.3.5 Protein test

Principle of protein was determined by acidimetric titration of the sample after digestion with hot sulfuric acid in the presence of a catalyst by conversion to ammonium sulfate, ammonia, sodium hydroxide, displacement and distillation into boric acid. The content of protein was calculated from multiplying the nitrogen content which found in several conventional conversion factor.

Figure 8. Distillation unit

Materials:

Chemicals: Catalyst tablets of K_2SO_4 - 3.5 g, Se - 3.5 mg; distilled water; potassium bicarbonate ($KHCO_3$), hard methyl orange solution 0.1%.

Apparatus: Mineralization block; distillation unit, mineralization tube, Erlenmeyer flask (volume 300 ml), Burettes, with automatic mixing; stirrer, magnetic, Analytical balance capable of weighing ± 0.001

For protein test we need to prepare some solutions and chemical concentrations. Preparation should fallow by this step:

Preparation: 0.1 g of dye was dissolved in distilled water in a 100 ml volumetric flask up to the mark with distilled water.

Sulfuric acid (H_2SO_4), concentrated sulfuric acid (H_2SO_4) solution of 0.2 N

Preparation: 6 ml of concentrated sulfuric acid H_2SO_4 in a 1000 ml volumetric flask and dilute to the mark with distilled water.

Determining factor: 0.6 g of potassium hydrogen carbonate $KHCO_3$ are dissolved in 30 ml of distilled water, add 3 drops of methyl orange and titrate with 0.2 N sulfuric acid H_2SO_4 into the first orange colour; titration flask was covered with a watch glass and the solution is gently boiled to remove carbon dioxide CO_2; solution was cooled and tetrated into permanent orange colour factor = 29.97 / H_2SO_4 Consumption

Sodium hydroxide (NaOH) solution of 40%

Preparation: 400 g of NaOH are dissolved in distilled water and 1000 ml volumetric flask up to the mark with distilled water.

Boric acid (H_3BO_3) of 1% solution

Preparation: 50 g of boric acid H_3BO_3 were dissolved in 1000 ml of hot distilled water and, after cooling and addition Tashiro indicator with distilled water to a volume of 5000 ml

Tashiro indicator solution

Preparation: 0.05 g of bromocresol green and methyl red 0.035 g was dissolved in 85 ml ethanol and added to 5000 ml 1% solution of boric acid

Control: to 100 ml of distilled water was pipetted 25 ml of 1% boric acid solution with Tashiro indicator, the solution is to have a light gray colour.

Operating procedure distillation unit (Figure 8):

Switching on the main switch in the ON position I currently run the cooling water. Preparation device (sweating) button with a needle, switch to MANUAL and the down arrow to set the pace STEAM ON, confirm with the ENTER key again after finishing the ENTER button.

Preparation device (analysis) button with a needle, switch to ANALYSE and press ENTER to confirm the selected program, device indicates ANALYSE READY.

Distillation of the sample after inserting the sample cuvette into a blank template and door closure devices automatically starts distillation

Distillation of a new sample can be started only if the device indicates ANALYSE READY. Off button with a needle, switch to MANUAL and down arrows to set the pace STEAM ON, confirm by pressing ENTER after completion press the power switch to O, simultaneously conclude cooling water.

Workflow:

To an accuracy of 0.001 g into the digestion tube weigh 1 g of sample, add 2 tablets catalyst and 10 ml concentrated H_2SO_4 mix thoroughly and add a further 10 ml of concentrated sulfuric acid, which flushes adhering to the sample cuvette. Carefully placed in mineralization block. Tube is positioned vertically in the mineralization block is provided wherein a constant heating at 420 ° C for 90 min for 105 min or wheat with other grains occurs mineralization (until clarification liquid). The contents of the digestion flask was allowed to cool. After cooling and addition of 60 ml automatic (50 ml) of distilled water is used for automatic steam distillation under addition of 70 ml (80 ml) - 40% sodium hydroxide, the resulting ammonia is collected into the receiver with 30 ml of 1% boric acid and Tashiro indicator. The amount of ammonia is determined by titration with 0.2 N sulfuric acid. Protein content calculated by the percentage in dry matter according to the formula.

Calculation of protein content (%):

$$\frac{(0{,}28 \text{ x conversion factor x consumption } H_2SO_4 \text{ x } H_2SO_4 \text{ factor}) \text{ x } 100}{\text{Dry matter}}$$

Conversion factors: wheat, rye 5.7; Others 6.25.

The result is the arithmetic mean of the values obtained from two determinations, provided that the conditions of repeatability.

4.4 Baking test

Baking test is during preparing and after baking of buns determining external and internal characteristics and quality, quantity of weight, volume.

Materials: 300g flour, 12 g yeasts, 3g butter, 4, 5 g sucrose, 5,1 g salt, water, malt flour, tray handling dough container covering loaves, baking, blowing on baked goods. Devices: Farinograph, proofer, oven, baking volume meter, caliper.

Before baking and attempt to turn on the thermostat Farinograph, proofer, oven, so that the instrument warm up to operating temperature, which is 30 ° C for Farinograph and proofer and 240 ° C for the kiln.

Weighed test flour and other raw recipe to Farinograph kneading machine. Enable mixing and recording equipment. Adding water from a burette previously preheated to 30 ° C. The amount of water added depends on the severity of the flour, which was determined at Farinograph evaluation. Orientation should be water consumption by about 6% lower than the Farinograph water holding capacity. The consistency of the dough should be between 550 - 650 BU. The dough was allowed to stir for a further 5 minutes after the first drop in the curve. Then it take out the kneading machine and let rise for 45 minutes in a proofer at 30 ° C, covered bowl. Then divide the dough into loaves weighing 80 g around to shape the lumps buns on greased baking sheet and set aside, covered in proofer finish rising 50 minutes. After proofing sheets put in an oven at 240 ° for evaporating pour into the hole on top of the furnace 70 ml of distilled water. Buns bake for 14 minutes, then remove from the oven, let cool for 90 minutes and then evaluate. The baking test have been evaluated by measuring size, volume of 3 pieces, weight, shape, technical dough properties, crust colour, taste and smell of the bread.

4.4.1 Farinograph ratings

Before the measuring Farinograph on the thermostat so that the machine warmed up to operating temperature - in 30°C. Weighed 300 g flour and blown into a kneading machine. Enable mixing and moving the paper and leave for 1 minute. Then, from the burette admit distilled water preheated to 30 ° C up to 500 BU consistency. Water is added at once, and if it fails, necessary to repeat. The dough adhering to the walls are scraped off and cover with a kneading machine. Graf leave record, 12 minutes from the pronounced contraction curve. The development time of dough in minutes from the start of kneading to the point where the curve has reached the maximum value. Stability of dough - indicates the time in minutes that the dough retains maximum consistency since evolution. The drop to dough consistency is the difference between the values of 500 BU a value that indicates the centre of the curve. Dough resistance is the sum of the time evolution of dough stability and dough in minutes.

4.4.2 Evaluation of bread

Height baking (cm) width and pastries (cm) was measured with a caliper. Bread volume (cm^3) was measured with the help of rape or millet. Fill the container rape seeds, ruler align with the edge of the container. Then the container sprinkle about 2/3 seeds and put in their place 3 buns then again sprinkle rape. Excess rape is collected into a measuring cylinder and subtract the volume.

The volume meter is used for objectification measurement. Specific bread volume (cm^3 per 100 g of product) buns, where we measure the volume, even considering a measured volume of bread per 100 g. For external and internal property will gave points from 1 to 4, after will calculate by plus this points (Table 7).

Volume yield - V (cm^3 per 100 g of flour), a measured volume 3 buns per 100 g of flour. The amount of flour needed to 3 buns is calculated according to the relation:

Weight flour 3 buns = 240 x 300 / total mass of dough;

5 RESULTS

Composite flour is very popular in the world. Our aim was determine baking quality of composite wheat and hemp flour, find significant comparison in nutritional value and in physical characteristics of the dough.

5.1 Rheological method

Rheological method has a lot of various test, nevertheless for determination physical characteristics of dough and composite flour was used Farinograph and Extensograph. Every flour have itself physical characteristics such as water absorption, degree of softening, extensibility and resistance.

Table 3. Farinograph – physical characteristics of the composite flour dough

Samples	Water absorption (%)	Dough development time (min.)	Dough stability time (min.)	Degree of softening (BU)
I. Wheat flour	64.5	3	3.5	40
II. W+ H flour 5%	65	3.5	5	40
III. W + H flour 10%	65.6	4	3.7	50
IV. W + S flour 5%	65.5	3	7 ¾	40
V. W + S flour 10%	67	3.5	5.5	40
VI. W + Q flour 5%	64.6	4 ½	6	40
VII. W + Q flour 10%	65	4	5.7	50

Below to table 3, water absorption in composite soya bean 10 % had 67 %, composite hemp 10% had 65.6 % of absorption and this samples the highest than another samples, but wheat flour had 64.5% (less then another samples). Dough development time have been from 3 to 4 ½ minutes. Dough stability time were higher in composite soya bean 5% - 7 ¾, in composite quinoa 5% - 6 minutes, but another samples were from 3.5 - 5.7 minutes. Dough stability time of wheat flour – 3.5 minutes was lower than another. Degree of softening have been between 40 to 50 B.n. The highest degree of softening had 50 BU. It was composite hemp flour – 10% (Table 3).

Extensograph is main dough parameters which showed that wheat flour has good resistance than replaced hemp flour. In table 6, resistance of wheat dough from 300 EU to 385 EU, in composite hemp flour 5% and 10% had from 282 – 320 EU. The best resistance of dough had composite quinoa flour from 380 EU to 410 EU. Extensibility of dough was different in each flour (Figure 9). All samples result were depended from proving time (Table 8).

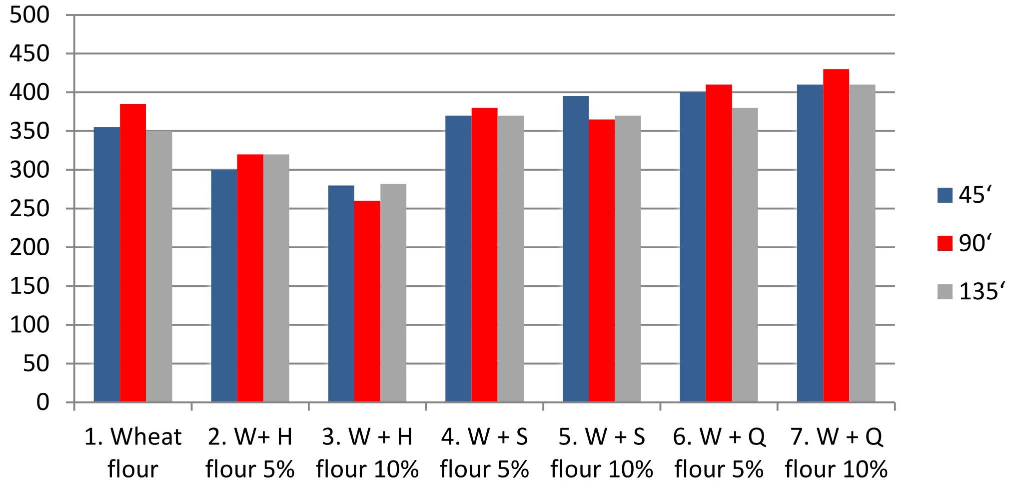

Figure 9. Maximal resistance (EU)

Wheat flour had extensibility between 180 – 240 mm, and composite hemp flour had lower between 145 – 200 mm. The best extensibility of dough had composite soybean is 160 – 280 mm and quinoa flour is 180 – 265 mm (Figure 10).

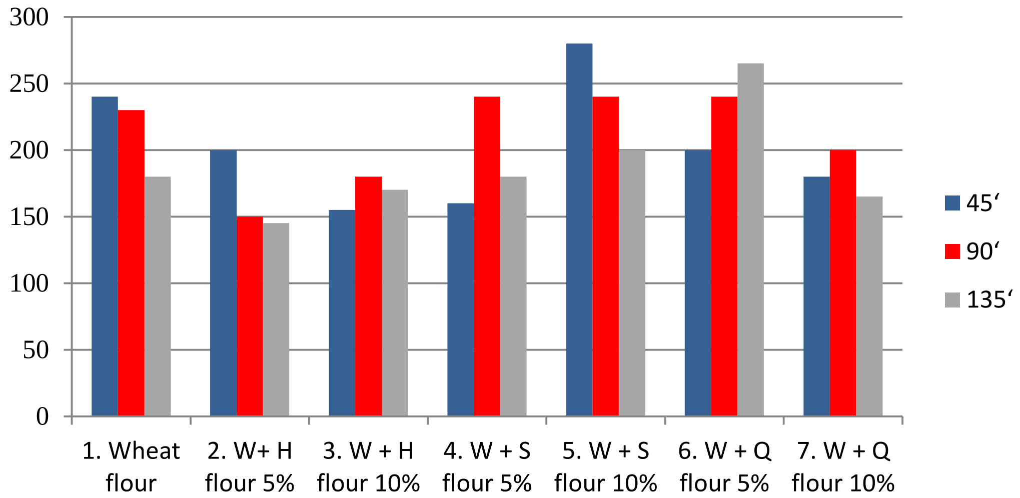

Figure 10. Extensibility (mm)

5.2 Analytical analyzes

During analytical analyzes found some interesting results of nutritional values (Table 4). In moisture tested that wheat flour had 13.22% more than in composite hemp flour 5%-10% had 12.94 %– 12.24%. Nevertheless the best was composite quinoa flour 5% had 13.28 % of moisture. Ash test had significant quantity as 1.4% in dry matter of composite hemp flour – 10%. However wheat flour had small amount of ash – 0.5 % in dry matter. It mean that composite hemp flour, soya bean flour and quinoa flour had more ash in dry matter than in wheat flour. Falling number as determination of enzyme activity of flours were higher in composite hemp 5% - 442 sec. and in composite quinoa flour – 479 sec. But wheat flour was lower – 396 sec. and composite quinoa flour -5 % was the lowest – 374 sec.. Main very important of nutritional value of flour is gluten and protein. Gluten percentage of dry matter higher in composite soya bean 10 % flour – 31.9%, in wheat flour – 32.2 % and in composite hemp four 31%. But gluten index was higher in composite soybean 5% - 97 and in composite hemp flour 5-10% - 95 – 90.3, the lowest composite quinoa 10% - 84. Protein of percentage of dry matter was the highest in composite hemp 10 % - 15.1% and the lowest was wheat flour – 12.3%.

Table 4. Nutritional value of composite flours and wheat flour.

Samples	**Moisture (%)**	**Ash (% in dry matter)**	**Falling number (sec)**	**Gluten (% in dry matter)**	**GI - gluten index**	**Protein (% in dry matter)**
I. Wheat flour	13.22	0,5	396	32,2	95.7	12.3
II. W+ H flour 5%	12.94	1,02	442	31	95	13.2
III. W + H flour 10%	12.24	1,4	431	31	90,3	15.1
IV. W + S flour 5%	13.14	0,7	433	31,15	97	13.08
V. W + S flour 10%	12.44	1,02	430	31,9	92,8	14.1
VI. W + Q flour 5%	13.28	0,6	374	31,5	90,3	12.5
VII. W + Q flour 10%	13.1	0,7	479	31,4	84	14.8

5.3 Baking test

Below table 9, volume 3 pieces of bread was more in wheat buns and in composite quinoa buns – 800 ml. The lowest was composite hemp flour -10 % - 580 ml. Because of lowest volume of composite hemp flour - 10% was lower in specific bread volume too -

267 ml per 100 g of bread. Height and width of bread samples were different. Height and width ratio despite that composite hemp flour-10% bread was lower in volume, but composite hemp flour – 5 % was higher in this case and composite quinoa flour bread too - 0.64. The lowest was composite soya bean – 10% - 0.48. From following parameters wheat flour was the best. Composite hemp flour bread had interesting and different smell, colour of crusty and testy (Figure 11).

Figure 11. Baked buns (a) Wheat flour; b) Composite hemp flour – 5%; c) Composite hemp flour – 10%; d) Composite soybean flour – 5%; e) Composite soybean flour – 10%; f) Composite quinoa flour – 5%; g) Composite quinoa flour – 10%).

In investigated work was comprised significant property of buns and nutrition value of composite flour. By table 6, in baking test for external and internal characteristics gave points and calculated. The wheat buns have good property (28 points) in volume and height with weight. In nutritional value such as gluten was higher, but in protein and ash content was lower. The composite flour showed significates in nutritional value than wheat flour. Nevertheless some composite buns had good external and internal shape such as composite quinoa 5 - 10 % (19 - 24 points), composite soybean 5 – 10% (19 – 18 points) and composite hemp 5% (18 points). The composite hemp 10% was the lowest (13 points), but in nutritional value was the highest as protein - 15.1 % and ash 1.4%. The height and weight ratio was the highest composite quinoa flour 10% – 0.64, composite hemp flour 5% - 0.64 and composite soybean flour 5% - 0.62. The wheat flour was in the middle (0.61) of height and weight, but the lowest were composite soybean flour - 0.48 and composite hemp flour – 10% - 0.49 (Table 5).

Table 5. Significant property of buns and nutrition value of composite flour

	Wheat flour	W + H 5%	W+H 10%	W + S 5%	W+S 10%	W + Q 5%	W+Q 10%
baking test	28	18	13	19	18	19	24
volume 3 pieces of bread (ml)	800	700	580	720	680	780	800
specific bread volume (ml per 100 g of bread)	378	336	267	345,9	329,1	358	389
height / width pastries (cm)	5,9/9,5	5,5/8,5	4,5/8,5	5,6/8,7	5,0/10	5,6/9,2	5,8/9
height / width ratio	0,61	0,64	0,49	0,62	0,48	0,61	0,64
protein (% in dry matter)	12.3	13.2	15.1	13.08	14.1	12.5	14.8
gluten(% in dry matter)	32,2	31	31	31,15	31,9	31,5	31,4
ash(% in dry matter)	0,5	1,02	1,4	0,7	1,02	0,6	0,7

6 Discussion

The goal of study was find out composite flour feature comparable to wheat flour which added values as balanced nutritional composition and proper rheologic properties.

For baking quality of composite flour determined by analytical test, rheological methods and baking test. Analytical test showed that composite flours had higher nutritional value by compare wheat flour. The results nutritional worth such as protein, ash were higher in every composited flour, but in wheat flour gluten content was higher (Table 7). In Olaoye *et al*. (2006) reported that composite soybean flour 5-10% had 7.26 – 8.03% higher protein then in wheat flour and supplementation wheat flour with soybean flour would greatly improve protein quantity of bread. Protein content in investigated research the highest was composite hemp flours 10% - 15.1% and in composite quinoa - 10 % - 14.8 %. It mean that if we will add more percentage of composite flour, nutritional value will be higher. Švec and Hrušková (2015) published from 5 to 15% composite hemp flour had good source of protein but 20% composite hemp flour was the highest. Actually, hemp flour is lower than in soya bean, hemp is 33% protein, nonetheless soybean more 35%. This was protein content of whole soya bean and hemp flour (Gregory, 2010). In invested research composite soya bean flours 5 – 10% was lower (13.08-14.1%) than composite hemp flours 5 - 10 % (13.2 – 15.1), but wheat flour the lowest.

The ash content in wheat flour was the lowest (0.5 %), nevertheless higher amount were composite flours. Ndife *et al*., (2011) wrote by comprising whole wheat flour with composite soya bean flours from 10 to 40% that wheat flour was the lowest in ash content than composite soya bean flour. Rosell *et al*. (2009) researched an Andean crops such as quinoa, kaniwa, kiwicha and tarwi flours. All flours have high protein contents and ash content of quinoa flour was higher – 2.09 % than wheat flour – 0.5%.

Falling number determination of amylolytic activity was higher in composite flours except composite quinoa - 5% (374 sec) and wheat flour (396 sec). Švec and Hrušková (2014) by comprising and estimating amylolytic activity composite hemp flour from 5% to 20% and wheat flour, wheat flour was the lowest – 310 sec. In Falling number increase the amount of quinoa flour will produce a rise in Falling number values. The decrease in 5 % and 10 % composite quinoa flour may be the result of delusion effect. Wheat flour had –

248 sec, composite quinoa 5% - 213 sec, composite quinoa 10 % - 213 sec, composite quinoa 15% - 246 sec. (Enriquez *et al*., 2003).

The gluten content was higher in wheat flour, but composite soybean flour showed good amount too in our study. Ribotta *et al.*, (2005) only soybean flour mixtures with wheat flour containing denatured proteins were able to form gluten.

Rheological methods used by Farinograph and Extensograph tests. In Farinograph test water absorption of wheat flour (64.5%) was lower than in composite flours such as composite soya bean flours 5% - 10% had 65.5 - 67%. Fenn *et al.,* (2010) wrote that mixing soya bean flour with wheat flour increased Farinograph water absorption and increased protein contents. Water absorption of composite soya bean 5% and 8% had 66% - 69%, wheat flour had 63 %. Farinograph establishes the flour action during baking test. It submits the elasticity and plasticity of dough during mixing on invariable temperature. Good quality flour will have degree of softening between 30 and 50BU and stability value will not lower 7 minutes. The level of softening of dough presented that supplementation the lower quantity of quinoa flour did not increase deterioration of gluten. The stability of pseudocereals dough had well reduced concentration range. Commonly, supplementation of wheat flour with pseudocereals diminished the mechanical resistance index with control dough (Jancurova *et al*., 2009). Stability of wheat flour (10 min) was higher than in composite quinoa 5%, 10% and 15% (9 min, 8 min and 7 min) (Enriquez *et al*., 2003). Stability in investigated work was lower in wheat flour 3.5 min, nevertheless composite flours were higher (3.7 -7 min). Extensograph test has resting time from 45, 90 and 135 min. In resting time changed on extensibility and soybean concentration were varied. This parameter increased with the addition of 1.0 or 1.5% of composite soybean to wheat flour at 45 resting times. Resting time increases such as 90, 135 minutes, the extensibility values of soybean flours not affected as compared with wheat flour (Rosals – Juares. 2007). The study of Wang, *et al*., 2013 was explaining their study on evaluation of the influence of hemp addition and extrusion conditions on properties of dough and bread. The different hemp/rice flour ratio was mixed with 15% ratio of wheat flour. In that flour assays, when addition of hemp inhibited the decrease of peak viscosity and extrusion greatly decrease the past viscosity. Because of hemp addition the onset gelatinization temperature was extended and increased the weakness and extensibility. On dough properties extrusion increased water absorption, weakness, extensibility, volume after fermentation, and decreased the stability time and elasticity. On bread properties with the addition of hemp increased the bread specific volume and decreased the hardness during storage time.

In baking test volume of buns were higher in wheat flour and composite quinoa flour – 10% - 800 ml. Other composite flours had good quality too, but composite hemp flour - 10% was the lowest. Enriquez *et al.,* (2003) has composite quinoa 5 – 10% does not influence to specific loaf volume. However composite quinoa flour 15% has high amylase activity, which increased in gas production and volume of loaf was higher. The higher additional hemp value, the lower bread volume in case of composite hemp flour evaluation. Conversely, a little amount increase hemp bread volumes. Similarly to that, composite hemp buns crumb texture as well changed - pores density increased and size softly decreased (Švec and Hruškova, 2013.). Buresova *et al.*, (2014) published that determination of bread volume the highest made from wheat flour (432 ml), but gluten - free quinoa flour (287 ml) was higher than another flours.

The quinoa flour had higher source of protein, fat and ash than in rice and corn flours. Interestingly that energy value of quinoa flour was lower than other cereals (Dogan and Karwe, 2003). In investigated research, wheat flour was the highest in energy of the dough (in 45 min – 95, 90 min – 115 min and 135 min - 102 cm^2), but other composite flours showed good results too, except composite hemp flours 5 – 10%. Nevertheless, a composite quinoa flours and composite soybean flours were the highest in 45 minutes between 95 to 105 cm^2. The composite hemp flours 5 – 10% were the lowest from 61.3 to 79.3 cm^2. The wheat dough increased weakening when increased mechanical energy and temperature. It mean that energy of wheat dough higher, because of weakening of dough (Pastukhov and Dogan, 2014).

Edema *et al*., (2005) evaluated corn - soybean composite flours 10 – 20% with comprising separately soybean and corn flours. Soybean flour had the highest protein, ash content and composite corn – soybean flour had good source too, but corn flour was the lowest. The volume of composite corn – soybean flour 10 – 20 % was the highest – 116.9 - 116.5 ml, but soybean flour was lowest – 114.5 ml. Crust color of soybean was dark brown and composite corn – soybean flours were brown color. Soybean bread`s crumb had regular porosity and moderate elasticity, small cracks on surface crusts. In investigated work, a volume of composite soybean flours 5 – 10% was 720 – 680 ml. Crust color was in composite soybean flour 5 % had more light and gloss colour, but composite soybean flour 10 % was as typical pastry. Rosell *et al*., (2009) quinoa flour with adding wheat flour created a good range of external and internal characteristics. The crust color decreased when quinoa flour proportion increased and buns with higher proportion of quinoa flour had dark color. Composite quinoa flour 25% had the best crust color by comprising wheat flour. Same work were published by Park *et al*., (2005) that composite quinoa flour 30 % showed poor extensile gluten and hard crumbs. Nevertheless, composite quinoa 25% did not show hard crumb, vice versa very well result by comprising wheat flour. Supplementation of quinoa with wheat flour analyzed in breads with varied sensory characteristics. Supplementation of quinoa flour with wheat flour consist options to improve the nutritional value of buns and quantity and quality of protein, ash or bioactive components (Rosell *et al*., 2009).

7 CONCLUSION

From presented study, we concluded that mixing different types of hemp, quinoa and soybean with wheat flour, advanced features in rheological, nutritional value and baking test of bread. Nutritional value higher in composite flour than in wheat flour such as protein source composite hemp flour – 10 % had – 15.1%, but wheat flour had – 12.3% in dry matter. Gluten source was higher in wheat flour - 32.2% as usual, but surprisingly composite soybean flours 5 - 10% had 31.9 - 31.15 % in dry matter (Table 9). I think, that it can be use in future research without replacing, only by analyzing soybean flour.

Composite flours needed more absorption water than in wheat flour and composite quinoa flour had higher resistance. It mean composite flours have strong gluten and required more strength for stretch, extension the dough.

Commonly, wheat buns were the best in baking test. Nevertheless in composite flours buns had specific results too. Composite quinoa flours 5 – 10 % showed that volume of 3 – pieces of buns had 800 – 780 ml as wheat buns – 800 ml. Composite hemp – 10 % unfortunately was the lowest in baking test – 13 and volume 3 pieces of bread – 580 ml, however nutritional value was higher as ash – 1.4 % in dry matter (Table 9). Hemp flour had lower gluten and from this cannot rise in volume itself. By adding wheat flour can rise and composite hemp – 10% properties were lower. External and some internal characteristics was not so significant, but testy and smell had nutty flavour.

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9 ANNEX

Table 6. Weight of the test sample depending on the water content

Content of water (%)	**Sample weight, (g)**	**Content of water (%)**	**Sample weight (g)**	**Content of water (%)**	**Sample weight (g)**
9,0	6,40	12,0	6,70	15,2	7,00
9,2	6,45	12,2	6,70	15,4	7,05
9,4	6,45	12,4	6,75	15,6	7,05
9,6	6,45	12,6	6,75	15,8	7,10
9,8	6,50	12,8	6,80	16,0	7,10
10,0	6,50	13,0	6,80	16,2	7,15
10,2	6,55	13,2	6,80	16,4	7,15
10,4	6,55	13,4	6,85	16,6	7,15
10,6	6,55	13,6	6,85	16,8	7,20
10,8	6,60	13,8	6,90	17,0	7,20
11,0	6,60	14,0	6,90	17,2	7,25
11,2	6,60	14,2	6,90	17,4	7,25
11,4	6,65	14,4	6,95	17,6	7,30
11,6	6,65	14,6	6,95	17,8	7,30
11,8	6,70	14,8	7,00	18,0	7,30
12,0	6,70	15,0	7,00		

Table 7. Sensory evaluation of bread

Characteristics	Importance coefficient	4	3	2	1	0
Technical dough property	2	Very flexible, non-sticky	Flexible, non-sticky	Less flexible	Little elastic, slightly sticky	Inflexible, sticky
Shape of buns	1	Well domed	Medium - domed	Less domed	Round	Very low, irregular
Crust colour	1	Normal, typically pie	Darker shiny	Lighter shiny	The dark matte	Very light matte
Parcelace, breakdown of crust´s surface	1,5	Very good	Good	Less significant	Few significant	Imperceptible
Elasticity	1,5	Very good, fine	Good	Fine enough	Low, crumbly crumb	Inelastic, sticky
Crust porosity	1,5	Uniform, soft walls, medium pores	Less uniform, soft walls, medium pores	Uneven, rough walls, smaller cavity	Uneven, rough walls, cavity	Uneven, rough walls, dense pores blew crust
Taste	2	Very good, typical pastry	Good	Less good	Sickly	Foreign taste, odor foreign
Smell	-	-	-	-	-	-

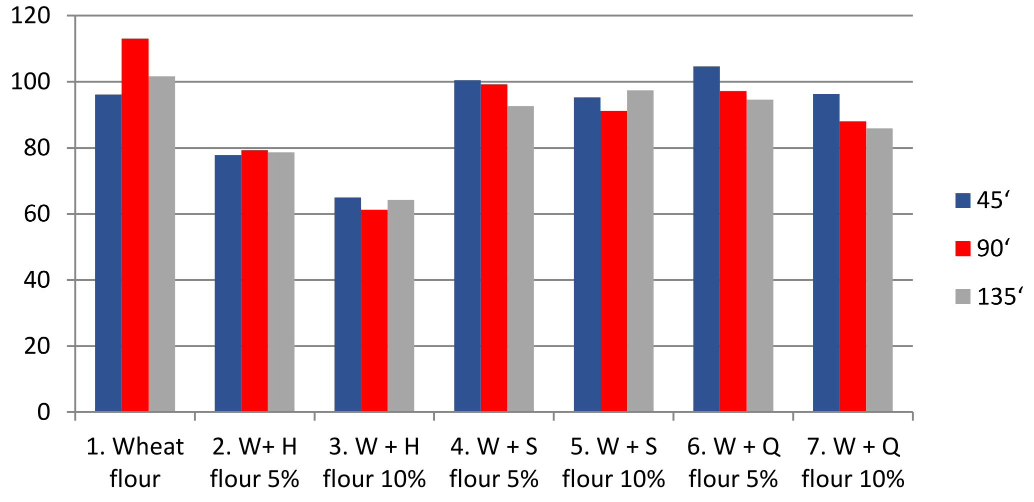
Table 8. Extensograph – physical characteristics of the dough

Samples	**Proving time (min.)**	**Maximal resistance - R_M (maximum) (EU)**	**Resistance (at konst.deform) R_{50} (EU)**	**Extensibility – d (mm)**	**Extensogr. Energy-W (cm^2)**	**R/E (ratio number)**
I. Wheat flour	**45‘**	355	300	240	96.1	1.25
	90‘	385	339	230	113	1.5
	135‘	350	310	180	101.6	1.7
II. W+ H flour 5%	**45‘**	300	280	200	77.8	1.4
	90‘	320	240	150	79.3	1.6
	135‘	320	240	145	78.6	1.6
III. W + H flour 10%	**45‘**	280	250	155	65	1.6
	90‘	260	240	180	61.3	1.3
	135‘	282	260	170	64.3	1.5
IV. W + S flour 5%	**45‘**	370	300	160	100.5	1.8
	90‘	380	340	240	99.2	1.4
	135‘	370	300	180	92.6	1.6
V. W + S flour 10%	**45‘**	395	340	280	95.2	1.2
	90‘	365	300	240	91.2	1.25
	135‘	370	300	200	97.4	1.5
VI. W + Q flour 5%	**45‘**	400	320	200	104.6	1.6
	90‘	410	340	240	97.2	1.4
	135‘	380	320	265	94.6	1.2
VII. W + Q flour 10%	**45‘**	410	318	180	96.3	1.7
	90‘	430	370	200	88	1.85
	135‘	410	300	165	85.9	1.8

Table 9. Baking test

Samples	1	2	3	4	5	6	7
volume 3 pieces of bread (ml)	800	700	580	720	680	780	800
specific bread volume (ml per 100 g of bread)	378	336	267	345,9	329,1	358	389
height / width pastries (cm)	5,9/9,5	5,5/8,5	4,5/8,5	5,6/8,7	5,0/10	5,6/9,2	5,8/9
height / width ratio	0,61	0,64	0,49	0,62	0,48	0,61	0,64
technical	4	3	2	3	2	2	3
dough properties	Very flexible, non-sticky	Flexible, non-sticky	Less elastic	Flexible, non-sticky	Less elastic	Less elastic	Flexible, non-sticky
product shape	4 Good domed	3 Moderately domed	2 Less domed	3 Moderately domed	2 Less domed	3 Moderately domed	3 Moderately domed
product appearance (Crust colour)	4 Normal , typical pastry	1 Dark matte	1 Dark matte	2 More light and gloss	4 Normal , typical pastry	3 More dark and gloss	4 Normal , typical pastry
Parcelace , breakdown of crust´s surface	4 Very good	2 Less pronounced	2 Less pronounced	2 Less pronounced	1 Small significant	3 Good	2 Less pronounced
crumb properties (elasticity)	4 Very well, soft	3 Good	2 Sufficient	3 Good	3 Good	3 Good	3 Good
crumb porosity	4 Uniform, soft walls, medium pores	3 Less evenly, delicate walls, medium pores	2 Uneven, rough walls, smaller cavity	3 Less evenly, delicate walls, medium pores	3 Less evenly, delicate walls, medium pores	2 Uneven, rough walls, smaller cavity	3 Less evenly, delicate walls, medium pores
taste perception	4 Very good, typical pastry	3 Good	2 Less good, Have specific taste	3 Good	3 Good	3 Good	4 Very good, typical pastry

Energy – W (cm^2)



R/E (ratio number)