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Master Thesis

Influence of Different Buckwheat Flours on Selected Qualitative Parameters of Cookies

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Declaration

I declare that I am the author of this graduation thesis and that I used only sources and literature displayed in the list of references in its preparation.

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Signature

Abstrakt

Konzumace pohanky seté (*Fagopyrum esculenthum* Moench) má mnoho zdravotních benefitů především díky vysokému obsahu fenolických sloučenin v kroupách a vysoké antioxidační aktivitě. Cílem práce bylo otestovat možnost výroby sušenek s odstupňovaným podílem mouky z pohankových klíčků a vyhodnotit jejich vybrané kvalitativní vlastnosti. Pro výrobu sušenek byly připraveny směsi z pšeničné mouky a mouky z pohankových klíčků obsahující 0 %, 5 %, 10 %, 15 % a 20 % pohankových klíčků. Byly stanoveny charakteristiky mouky jako kapacita absorpce vody, kapacita absorpce oleje, objemová hmotnost, pěnivost, stabilita pěny, kapacita bobtnání. Dále byly stanoveny fyzikální (průměr, tloušťka, roztírací poměr, rozptylový faktor, hmotnost, tvrdost a barva) a senzorické vlastnosti sušenek (barva a vzhled, chuť, chuť, textura a celková přijatelnost). Přídavek pohankových klíčků do mouky ovlivnil především barevné vlastnosti sušenek. Z vlastnotí mouky obohacené pohankovými klíčky, byla ovlivněna kapacita absorpce vody a to pouze přídavkem 20% pohankových klíčků a kapacita bobtnání přídavkem klíčků 15 a 20%. Ze senzorických vlastností sušenek, byla negativně ovlivněna chuť a vůně sušenek a to pouze u 20% podílu pohankových klíčků v mouce. Proto můžeme doporučit pro výrobu sušenek přidání pohankových klíčků do pšeničné mouky do výše 15%.

Klíčová slova: pohanka setá, klíčky, sušenky, kvalita, senzorická analýza

Abstract

Common buckwheat (*Fagopyrum esculenthum* Moench) consumption has many of the health benefits mainly due to its high levels of phenolic compounds in groats and high antioxidant activity. The aim of the work was to test the possibility of cookies production with graduated proportions of different buckwheat flours from sprouts and evaluate their selected qualitative properties. Blends of wheat flour and buckwheat sprout flours containing 0%, 5%, 10%, 15% and 20% buckwheat sprouts, on a replacement basis, were prepared. Flour characteristics as water absorption capacity, oil absorption capacity, bulk density, foaming capacity foaming stability, swelling capacity were determined. Physical (diameter, thickness, spread ratio, spread factor, weight, hardness and color) and sensory characteristics of cookies (color and appereance, flavour, taste, texture and overall acceptability) were also determined.

The addition of buckwheat sprouts mainly affected the color properties of the cookies. Of the properties of flour enriched with buckwheat sprouts, water absorption capacity was affected only by the addition of 20% buckwheat sprouts and swelling capacity by the addition of 15 and 20% sprouts. Of the sensory properties of the cookies, the taste and flavor of the cookies was negatively affected only by 20% share buckwheat sprouts in flour. Therefore, we can recommend the addition of buckwheat sprouts to wheat flour up to 15% for the production of cookies.

Keywords: common buckwheat, sprouts, cookies, quality, sensory analysis

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Content

Introduction

The significance of a well-balanced diet in the prevention of numerous diseases is well known. Consequently, individual's nutrition should be aimed at disease prevention, improving the quality of life and attenuating the process of body ageing.

Common buckwheat (Fagopyrum esculentum Moench) has been a crop of secondary importance in many countries and yet it has persisted through centuries of civilization and entered into the agriculture of nearly every country where cereals are cultivated.

This crop is not a cereal, but it is usually classified among the cereals because of their similar usage. The buckwheat achenes are used as human food and also as animal especially poultry feed. Dehulled achenes (groats) are cooked as porridge or risotto and the flour used in the preparation of pancakes, biscuits, noodles, cereals, etc

Buckwheat is a rich source of nutrients in general. Therefore, buckwheat consumption has many of the health benefits mainly due to its high levels of phenolic compounds in groats and high antioxidant activity. Since buckwheat flour is gluten free, thus, replacing wheat flour in products with buckwheat flour will dilute the wheat gluten proteins and thereby help in preventing celiac disorders. Buckwheat act as a good replacement for wheat flour in in unleavened products e.g. cookies.

Different studies tested possible incorporation of various natural components like whey protein, mango peel powder, green tea powder, etc. in wheat flour, to improve functional and nutraceutical properties of products prepared from it (Gani et al. 2014; Ajila et al. 2010; Ahmad et al. 2015).

Nutritional properties of flour are determined by the quality of seeds and technological parameters of the milling process. The chemical composition of the seeds is influenced at each step of its production (the influence of breeding, fertilisation, storage etc.). Among these influences, germination should also be mentioned as a less expensive and efficient technology, that increases the bioavailability of protein and starch, increases contents of vitamins and minerals in seeds. Studies on the use of buckwheat sprouts or buckwheat sprout flour in food are still rare.

1 Literary Review

1.1 Classification of the Genus Fagopyrum

Buckwheat belongs to the family Polygonaceae. This plant group is generally referred to as the buckwheat, rhubarb or sorrel family.

The Polygonaceae family have leaves that vary in size, arrangement and shape, but the leaf stalk is always surrounded by a membranous or chaffy sheath at the base. The flowers are often grouped in clusters that are showy owing to the color of the sepals or bracts, for there are no petals. The fruit is a triangular achene, sometimes prominently winged.

There has been a great deal of interest generated over the past 10 years the classification of species from genus Fagopyrum. Ohnishi found six new species of buckwheat in China and he also created their classification. Ye and Guan (1992) suggested a key to the classification of 15 species that occur in the temperate areas of Euro-Asia, with approximately 10 species occurring in China. However, the key to classification of the genus Fagopyrum by Ohnishi (1995) is more complete.

1.2 Buckwheat Names in Major Languages

According to Li and Yang (1992) the ancient Yi people of Yunnan province called buckwheat er, common buckwheat er chi and Tartary buckwheat er ka. Common wild buckwheat was called qi chi er luo and wild Tartary buckwheat chi ruo er luo. The various names given to buckwheat have been used to trace its migration through Europe and Asia and still being used to confirm the origin of buckwheat. Today common buckwheat is called ogal in India, mite phapar in Nepal, jare in Bhutan, grecicha kul'furnaja in Russia and tatarka gryka or poganka in Poland. In French it is called sarrasin, blé noir, renouée, bouquette; in Italy fagopiro, grano saraceno, sarasin, faggina and in Germany Buchweizen or Heidekorn (Hammer 1986). It is referred to as soba in Japan where the same word also refers to buckwheat noodles. In Mandarin common buckwheat is called tian qiao mai while Tartary buckwheat is referred to as ku qiao mai.

It is interesting to note that in both China and Nepal, common buckwheat is referred to as sweet buckwheat while Tartary buckwheat is called bitter buckwheat. This probably relates to the taste of the flour as Tartary buckwheat leaves a very bitter taste after being eaten (Campbell 1997).

1.3 Botanical Description of Common Buckwheat

The common buckwheat plant is a broadleaved, erect annual with a single main stem and a branching habit. The main stem is grooved, succulent and smooth except at the nodes. The plants generally grow to 0.6-1.3 m tall. The stems are hollow and therefore are subject to breakage by high winds. They are also subject to breakage due to hail as they snap off where struck. They can recover from damage by branching from lower leaf axils.

The plants have a short taproot and fine lateral Roots producing a root system that is about 3-4% of the weight of the total plant. The plants can therefore suffer from extreme drought conditions. Prior to maturity, the stems and branches are colored from green to red. They become reddish brown at maturity (Wo et al. 2010).

The flowers of *F. esculentum* are composed of five petal-like sepals that are usually white (Figure 1.1), pink or dark pink. The flowers are showy and densely clustered in racemes at the ends of the branches or on short pedicels that arise from the axils of the leaves. This species is dimorphic, having plants bearing one of two flower types. The pin flowers have long pistils and short stamens while the thrum flowers have short pistils and long stamens. Flowers with pistils and stamens of similar length (Esser 1953; Marshall 1969) and lines with only one floral type (Marshall 1969; Fesenko and Antonov 1973) have been reported. The pistil consists of a one-celled superior ovary and a threepart style with a knoblike stigma and is surrounded by eight stamens. Three of the stamens closely surround the pistil and open outwards, while the other five are closer to the outside and open inward. Nectar-secreting glands are at the base of the ovary. New flower forms such as the one found by Marshall (1969) have short stamens and pistils and are well adapted to self-pollination. Dahlgren (1922) and Garber and Quisenberry (1927) reported the inheritance of the flower type in common buckwheat as monogenic.

The fruit of the plant has a single seed within a hard outer hull called achene (Figure 1.2). Achene is triquetrous, acute angle, longer than 5 mm, more thantwice the length of the persistent perianths, brown or black-brown, lucid (Campbell 1997).

Figure 1.1: Flowering common buckwheat (Campbell 1997)

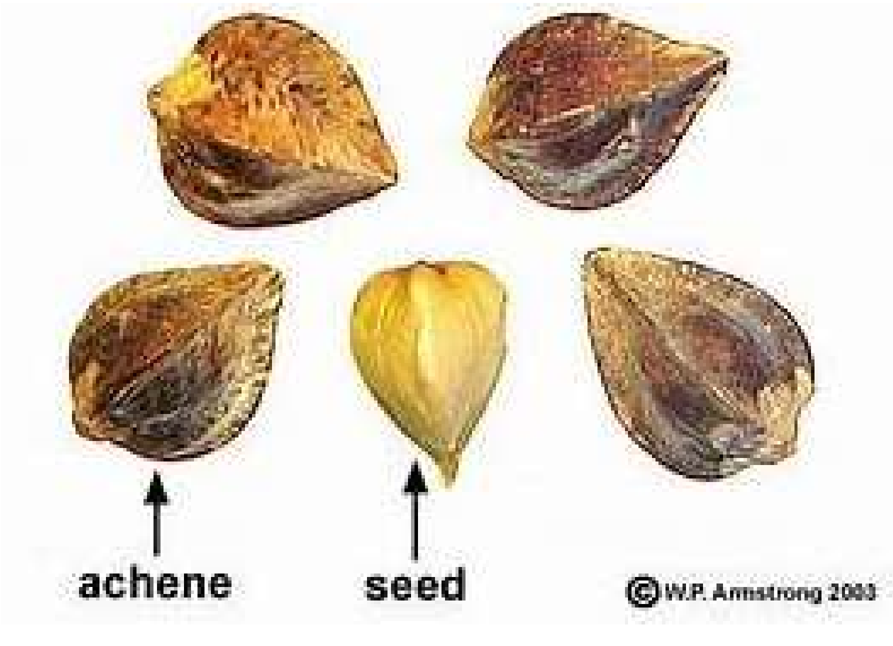

Figure 1.2: Achenes and seed (groat) of common buckwheat (Campbell 1997)

1.4 Buckwheat Production

Common buckwheat was domesticated possibly around 6000 BCE when it was first cultivated in Southeast Asia. The cultivation of this crop then spread to the Middle East, Europe, and Central Asia (Ohnishi 1998).

Buckwheat is a short season crop that grows well in less fertile as well as acidic soils. The major requirement is that the soil must be well-drained. Its growing period is as short as 10 to 12 weeks. Summer type cultivars are mainly grown in high-latitude region, and seen non-sensitive to photoperiod, autumn-type cultivars are grown in low-latitude region and behave as facultative short-day plants. The intermediate-type of buckwheat cultivar show a moderate photoperiodic sensitivity (Hara and Ohsawa 2013).

Todays, Russia (Table 1.1.) is the top buckwheat producing country in the world. Here, 712,047 hectares of land is used for buckwheat cultivation and about 700,000 of buckwheat was produced in 2014 according to data provided by FAO. China ranks number two in the world in buckwheat production producing 661,764 tons of the crop in 2014. Ukraine comes next with a production of 167,440 in 2014 ((Worldatlas 2022).

Table 1.1: World production of common buckwheat in 2022 (Worldatlas 2022)

Rank	Country	Area harvested (ha)	Production (tonnes)
1	Russia	712,04	700,000
2	People's Republic of China	708,000	661,764
3	Ukraine	136,700	167,440
4	France	30,100	111,300
5	Poland	62,710	83,499
6	United States	78,000	83,000
7	Brazil	49,000	64,000
8	Kazakhstan	64,600	46,500
9	Lithuania	37,400	35,600

1.5 Uses and Importance of Buckwheat

The buckwheat is harvested to serve as food for people. Buckwheat noodles are commonly consumed in Tibet and northern China. In India, buckwheat flour is used to prepare food items during the Hindu fasting days since consuming wheat or rice is prohibited during such fasting periods. During this time, Indians make buckwheat pancakes, buckwheat pakoras, etc. Buckwheat noodles are common within Japanese cuisine. Buckwheat grouts are used to prepare porridge in parts of Eastern Europe and western Asia. Several other preparations of buckwheat are consumed worldwide. The nectar of the buckwheat plant is used to derive a dark-colored honey. Buckwheat is also used to prepare gluten-free beer. Buckwheat whiskey, buckwheat tea, and the Japanese buckwheat shōchū are other forms of beverages that use buckwheat (Pellegrini, 2014).

Hulls of the fruit are used as filling for upholstered goods. However, allergens present in the hull might trigger asthma in some people (Heffle and Pizzimenti et al 2014). In clinical studies, the findings suggest that the benefits of buckwheat grains may help reduce inflammation and unhealthy cholesterol levels while helping prevent heart disease ((Llanaj et al. 2022).

Rutin, a phytonutrient found in buckwheat, is an important antioxidant for cardiovascular health.This phytonutrient supports the circulatory system and helps fight high blood pressure and cholesterol (Quettier and Gressier 2000). Buckwheat intake is associated with lower levels of total serum cholesterol, in addition to lowering LDL “bad” cholesterol levels while increasing HDL “good” cholesterol.

Buckwheat grains contain protective phenolic compounds that can help fight cancer or heart disease formation. The addition of protein products of buckwheat to diet significantly lowered the level of cholesterol in serum, liver, and gall bladder of hamsters and suppressed the formation of gallstone by altering cholesterol metabolism (Tomokate et al. 2002).

This grain can act as an extraordinary therapeutic agent when treating the damage that is usually caused by so-called free radicals. Antioxidants usually support cell function by protecting DNA from damage and preventing inflammation or possible formation of cancer cells (Qin et al 2010).

When the researchers tested the effects of buckwheat in animal studies, they observed increased antioxidant activity in the liver, colon, and rectum of animals that ate buckwheat ((Durendić-Brenesel et al. 2013).

When buckwheat is fermented to create alcoholic beverages or certain types of sourdough bread, it can also provide valuable probiotics that nourish the digestive tract by transporting healthy bacteria to the intestinal flora (Petrova and Petrov, 2020).Buckwheat grains is more than safe for any type of person, especially if they suffer from celiac-type diseases or manifest some gluten sensitivity, that is, it can replace any cereal with the benefits of buckwheat grains (Giménez-Bastida et al. 2015).

The nutritional benefits of buckwheat grains supplies approximately six grams of dietary fibre in each cup serving, which helps fill you up and accelerates the transit of food through the digestive tract (important for regulating bowel movements) (Health-benefitsof.org 2022).

1.6 Chemical Composition of Common Buckwheat Achenes

1.6.1 Carbohydrates

Starch is the major component of the buckwheat achene. In whole grain of common buckwheat, the starch content varies from 59 to 70% of the dry matter, but the concentration can vary with the method of extraction and between cultivars. The chemical composition of the buckwheat starch from differs from the composition of cereal starches. The amylose content in buckwheat granules varies from 15 to 52% and its degree of polymerization varies from 12 to 45 glucose units (Mazza 1993).

Buckwheat starch granules are irregular in shape with noticeable flat areas due to compact packing in the endosperm. They vary from 4 to 11 nm in size. Buckwheat grains also contain 0.65-0.76% reducing sugars, 0.79-1.16% oligosaccharides and 0.1-0.2% non-starchy polysaccharides. Among the low molecular weight sugars the major component is sucrose. There is a small amount of arabinose, xylose, glucose and probably the disaccharide melibiose (Asano et al., 1970).)

1.6.2 Proteins

The protein content in common buckwheat varies from 7 to 21%, depending on the cultivar and environmental factors during growth. Most currently grown cultivars content 11-15% protein in the achene. The major protein fractions are globulins which represent almost one-half of all the proteins and consist of 12 to 13 subunits with molecular weights between 17 000 and 57 000. Other known buckwheat protein fractions include albumins and prolamins. Gluten is not presented in buckwheat achenes (Mazza 1986).

The albumin fraction, with a molecular weight of 7 000 - 8 000, consists of at least 12 proteins. Prolamin has been fractionated into three major and several minor components by SDS-PAGE. Buckwheat proteins are particularly rich in lysine. They contain less glutamic acid and proline and more arginine, aspartic acid and tryptophan than do the cereal proteins. Owing to the high lysine content, buckwheat proteins have a higher biological value than wheat, barley, rye and corn. About 56% of glutamic and aspartic acids were found in the form of amides (Marshall and Pomeranz 1982).

Digestibility of buckwheat protein, however, is rather low and this is probably due to the high fibre content (17.8%) in buckwheat, which may be desirable in some parts of the world. Buckwheat fibre is free of phytic acid and is partially soluble (Steadman, et al. 2001).

1.6.3 Lipids

Achenes of common buckwheat contain 1.5-3.7% total lipids. The highest concentration is in the embryo at 7-14% and the lowest is in the hull at 0.4-0.9%. Groats (dehulled achenes) of Mancan, Tokyo and Manor varieties of common buckwheat contained 2.1-2.6% total lipids, of which 81-85% were neutral lipids, 8-11% were phospholipids and 3-55% were glycolipids. The major fatty acids of common buckwheat are palmitic, oleic, linoleic, stearic, linolenic, arachide, behenic and lignoceric. Of these, the 16 and 18-carbon acids are commonly found in all cereals. The long-chain acids - arachidic, behenic and lignoceric -which represent approximately 8% of the total acids in common buckwheat, are only minor components in cereals (Mazza, 1993).

1.6.4 Antioxidants and Minerals

Whole achenes of common buckwheat contains 2–5 times more phenolic compounds than oats or barley, while buckwheat bran and hulls have 2–7 times higher antioxidant activity than barley (Table 1.2), triticale, and oats (Holasova et al. 2002, Zdunczyk et al. 2006).

Table 1.2: Total phenolics and antioxidant activities of whole grains and their milling fractions (Šiler-Marinković et al. 2017).

Sample name	Fraction	TPC[A] (mg GAE/g dried extract)	DPPH[B](IC50) (μg/ml)	FRAP[C] (nm Fe^{2+}/mg dried extract)
Buckwheat *(Fagopyrum esculentum)*	*whole grain*	50.7	76.7	49.43
	bran	62.6	69.2	57.42
	flour	41.8	105.2	40.19
Barley *(Hordeum vulgare)*	*whole grain*	16.4	176.6	15.56
	bran	19.4	155.8	18.5
	flour	12.1	191.9	12.3
Wheat *(Triticum durum)*	*whole grain*	16.2	206	12.15
	bran	18.9	195.2	15.35
	flour	11.9	232	11.9
Rye *(Secale cereale)*	*whole grain*	13.2	243	8.94
	bran	16.1	169.6	12.13
	flour	10.6	256	7.98

A. Total phenolics content (TPC) by Folin–Ciocalteu method.
B. DPPH radical scavenging activity.
C. Ferric reducing ability of plasma (FRAP).

Table 1.3: Content of eight essential minerals in buckwheat and cereals flour (Ikeda et al 2006)

Foods examined	Fe	Zn	Cu	Mn	Ca	Mg	K	P
	mg/100 g flour							
Buckwheat flour	2.86[b]	2.51[b]	0.52[a]	1.61[a]	12.4[b]	375[a]	450[a]	394[a]
Wheat flour	0.79[c]	0.80[d]	0.16[c]	0.43[c]	14.8[a]	35[c]	96[c]	124[c]
Rice flour	0.79[c]	1.53[c]	0.22[b]	0.93[b]	4.0[d]	42[c]	82[d]	113[d]
Maize flour	4.46[a]	2.70[a]	0.18[c]	0.89[b]	5.5[c]	254[b]	293[b]	356[b]

Compositions of eight essential minerals, i.e., iron, zinc, copper, manganese, calcium, magnesium, potassium and phosphorus, of buckwheat flour to those of cereal flours is given in Table 1.3.

1.7 Sprouted Grains in Food Products

The use of sprouts as an ingredient in food products is an interesting method of improving the nutritional value of food, as well as a safer way to ingest sprouts, since food processing can reduce microbial contamination and consequently decrease the occurrence of food-borne diseases. The germination process is well accepted by consumers, as well as the products made from the germinated grains or from their flour (Liu Y, et al 2018, and Boukid F et al 2018). The physicochemical and functional properties of cereal and legume flours change after sprouting (Lemmens et al., 2019, Liu et al. 2018).

Sprouts is gaining interest not only in the field of gourmet cooking or specialized nutrition, but also in the food industry as a source of nutrients and healthy secondary metabolites, with a short production time (Abellán et al , 2019, Sangsukiam et al., 2017).

Some studies evaluate the possibility of using sprouted grains as culinary ingredients or their flours as substitutes for ingredients with low nutritional value, such as wheat flour, which is widely used in bakery products (Ojha et al. 2018). Zilic et al. (2014) evaluated the content of tocopherols, B vitamins, as well as phenolic compounds in untreated and sprouted wheat grains. The germination significantly increased the levels of tocopherols, niacin, riboflavin, and free and bound phenolic compounds, therefore improving the nutritional value and antioxidant capacity of wheat grains and flours.

According to Tomé-Sánchez et al. (2020), germination at 21 °C for 7 days is ideal for the composition of the soluble phenolics and their bioactive properties in wheat sprouts. This information can be useful for the development of wheat products with high nutritional value and healthy properties (Tomé-Sánchez et al. 2020).

Swieca et al. (2017) replaced the wheat flour in bread by sprouted wheat flour at 5, 10, 15, and 20% levels. The addition of sprouted flour slightly increased the total protein content, although it has decreased its digestibility. Bread enriched with germinated wheat flour had more resistant starch, but less total starch, compared to the control bread. The authors concluded that the studied bread is indicated for special groups of consumers (obese, diabetic) (Swieca et al., 2017).

Tian et al (2019) observed changes in the baking properties, total phenolic content, antioxidant activity, and phenolic acid composition of three hard red winter wheat varieties during the early stage of seed germination (germination time up to 10 h). The results showed that during the early wheat germination phase, total phenolic content and antioxidant activity decreased. The sprouted grain whole wheat flour showed cooking properties comparable to the control flour (Tian et al 2019).

The effect of grain germination on gluten was studied by Boukid et al (2018), the authors evaluated the usefulness of germination in reducing the amount of gluten peptides associated with celiac disease. In addition, the use of sprouted grain whole wheat flour as an alternative to conventional flour was investigated.

The results showed that the germination process partially degraded the gluten, although it is still unsafe for patients with celiac disease. Regarding the comparison of the functionality of non-germinated versus germinated flours, the germination process significantly affected the retention ability as well as the swelling of the flours. The authors concluded that further rheological studies are needed to evaluate the potential of sprouted grain flours, thus optimizing their use (Boukid et al 2018).

So, the use of sprouted grains for human food seems to be promising. However, rigorous in-vivo studies are still required in order to clarify whether the increase in nutritional and bioactive content of sprouted grains results in biological benefits for lifestyle-related diseases (Nelson et al 2013).

1.8 Germination and Malting of Buckwheat Achenes

Buckwheat sprouts have a great potential for the production functional foods because are rich in flavonoids. During common buckwheat malting (for 144 h) among the studied phenolic compounds, rutin possessed the highest concentration (65.17 ug/g in the grain). Its content decreased first to 31.83 ug/g and later increased to 53 ug/g at the end of malting. The quercetin concentration rose from an initial 3.34 to 6.82 ug/g (Zhao et al. 2021).

Common buckwheat cold dehusking (without soaking in hot water or steam) was applied for dehusking the seeds. By such a method, the obtained groats maintained the germination ability. Among the phenolic compounds, the most abundant was rutin (0.1 mg/g DM in achenes). After 96 h of germination following dehusking, the rutin content was 0.9 mg/g DM. However, in the sprouts, the most abundant flavonoid was orientin (2.2 mg/g DM) (Živkovic et al. 2021).

There is increased protein, crude fiber, minerals, total and reducing sugars content whereas decrease in starch, total carbohydrates as well as energy due to germination (Table 1.4).

Tartary buckwheat sprouts have, in comparison to common buckwheat sprouts, an even better potential as functional food due to the excellent composition, including the high concentration of total flavonoids. Tartary buckwheat sprouts contain up to 54.4 g/kg of rutin (Yu et al. 2019). By the germination process, rutin is, in 72 h, enriched from 1.8 g/100 g DM (dry matter) in the grain to 2.1 g/100 g DM in the sprouted product, and the quercetin concentration is increased from 0.329 g/100 g to 0.385 g/100 g. According to Molinari et al. 2018) Tartary buckwheat grain contains also considerable amount of vitexin.

Tartary buckwheat sprouts in plasma-activated water have the total flavonoid content of Tartary buckwheat sprouts up to 15.81 mg/g of DM after 6 days of germination. This was three times higher than in the non-germinated achenes (Mravlje et al. 2021). Plasma-activated water treatment impacts the gradual upward trend in the concentration of flavonoids in the Tartary buckwheat sprouts (Wang et al. 2022).

Germinated Tartary buckwheat achenes are, according to Bhinder et al. (2022), a suitable material for producing functional gluten-free muffins. Tartary buckwheat malt could be used to prepare cookies and drinks. The flavonoid concentration in cookies made with Tartary buckwheat material was lower than expected regarding the level in the starting material (Molinari et al. 2018).

Table 1.4 : Proximate composition of germinated comon buckwheat (Shreeja et al. 2021)

Samples	Moisture (g/100g)	Protein (g/100g)	Fat (g/100g)	Ash (g/100g)	Crude fiber (g/100g)	Carbohydrate (g/100g)	Energy (Kcal)
BW	11.03±0.17	10.22±0.32	3.13±0.10	2.05±0.17	0.92±0.12	72.63±0.41	359.64±1.98
GBW	12.77±0.17	12.14±0.25	2.05±0.15	1.53±0.15	1.44±0.08	69.49±0.60	345.06±3.42
Mean	11.90	11.18	2.59	1.79	1.18	71.11	352.35
CD	0.17	0.29	0.03	0.17	0.10	0.20	1.74
SE of mean	0.05	0.14	0.01	0.05	0.01	0.07	4.94
CV%	0.43	1.26	0.06	2.88	1.60	0.09	1.40

Note: Values are expressed for the three determinants as mean ± standard deviation
BW – Buckwheat GBW – Germinated buckwheat

1.9 Cookies

Cookies are very popular baked products all over the world consumed nearly by all levels of society. This is due to its ready-to-eat nature, availability in different varieties and affordable cost. Cookies are made in a variety of style using an array of ingredients. They differ from other bakery products like bread and cakes because of having low moisture content, and long shelf life of the product (Ashwath Kumar and Sudha, 2021).

Cookie is derived from a Dutch word, koekje, which means little cake, while the sound of a cracker being eaten probably led to use of that name. Biscuit is a term used in the UK (and in New Zealand, Australia, and South Africa). The origin of the name biscuit comes from Latin, where bis coctus means twice-baked. There is also an Old French word, bescoit that has a similar meaning. It is thought that these products have been baked for thousands of years. The original process consisted of baking the biscuits in a hot oven and subsequently drying them in a cool oven. The basic characteristic that separates a biscuit, or cookie, from other baked products, such as bread or cake, is a moisture content below 5%. The lower moisture content protects cookies from microbial spoilage. (Zydenbos and Humphrey-Taylor 2003).

1.9.1 World Cookies Production

The global cookies market size was valued at USD 30.62 billion in 2018 and is projected to expand at a compound annual growth rate of 5.3% from 2019 to 2025. Growing product popularity, especially in emerging regions, is expected to be the key factor fueling the market growth. Moreover, high demand for chocolate cookies in developed economies like the U.S. (Figure 1.3 and 1.4), Germany, and the U.K. will boost the market further. Bakery manufacturers attract customers with innovative packaging solutions and by launching new flavor variants, such as pineapple (Grandviewresearch.com 2022).

Rising disposable income in emerging economies including China and India is projected to drive the product demand over the years to come. Rising product popularity as gifting option is also projected to boost the demand. Oats and digestive ingredients are the major ingredients in cookies. Certain cookies are gluten-free and high on energy. Now-a-days, new flavors with exotic add-ons are being introduced in the market as per the changing consumer demands (Grandviewresearch.com 2022).

Cookies prepared by shortened baking process are fat-free and a cohesive product of protein. Rising concerns over glutamic disorders and lactose intolerance in developed countries of North America and Europe are projected to increase the demand for gluten-free cookies. Supportive regulations aimed for ensuring organic labeling in food & beverage industry for the finished goods is forcing the manufacturers to improve label standards. These factors are also likely to have a positive impact on the market growth (Grandviewresearch.com 2022).

Availability of alternative products, such as chocolates, is also projected to pose a substitutional threat to the market. Moreover, high manufacturing costs result in the increased cost of the end products, which may hamper market development. On the other hand, increasing disposable income levels along with innovative strategic marketing techniques used to attract new consumers by key companies is expected to propel the market growth in future (Grandviewresearch.com 2022).

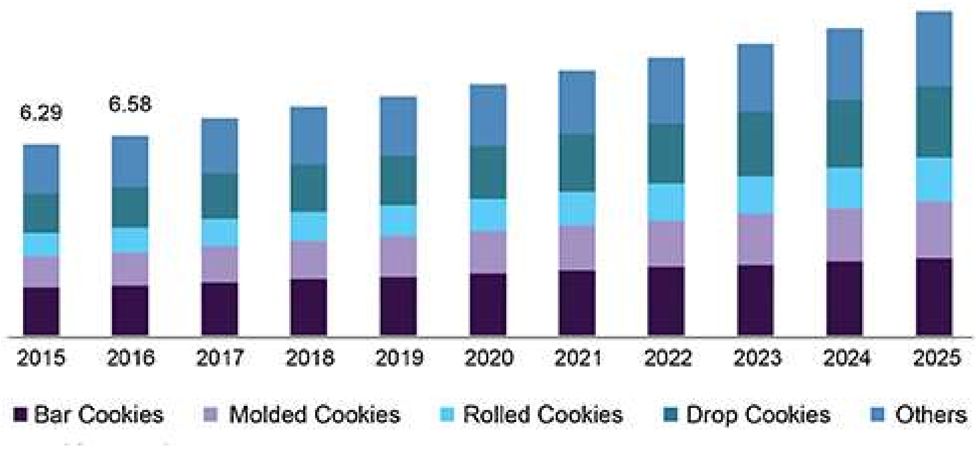

Figure 1.3: U.S. cookies market size, by product, 2015-2025 (USD Billion) (Grandviewresearch.com 2022)

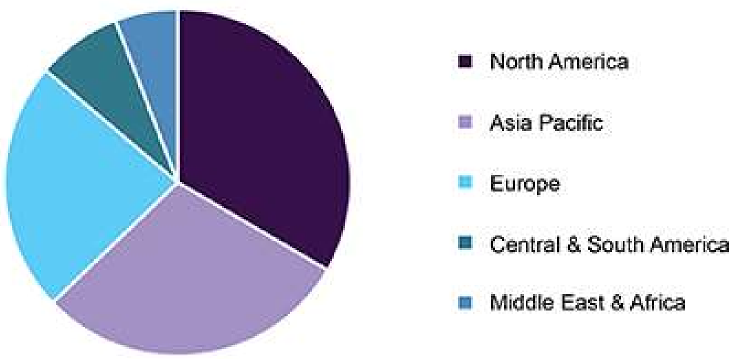

Figure 1.4 Global cookies market share, 2018 (Grandviewresearch.com 2022)

1.9.2 Characteristics of Cookies

Cookie is an unleavened crisp, made from wheat flour, shortening (Hydrogenated fat) and sugar & is usually made light by the addition of baking powder. Wheat flour constitutes the basic ingredient for cookies production because of its gluten proteins, which are not present in flour of other cereals (Ragaee and AbddelAal 2006). As opposed to bread, only a small amount of gluten is necessary in cookies and biscuits. Therefore, cohesive but not too elastic dough can be obtained and the dough can be sheeted and cut easily. Although, a considerable amount of information is available on wheat cookie dough rheology and quality attributes of the wheat cookie, only a few scientific articles have been published on gluten-free cookie dough and resulted baked products (De la Barca et al. 2010; Torbica et al. 2012; Hadnađev et al. 2013; Altındağ et al. 2015; Duta and Culetu 2015; Inglett et al. 2015; Mancebo et al. 2015, 2016).

Flour is the principal component of nearly all biscuits. A standard baking test has been developed and widely accepted for evaluating soft wheat flour for biscuit use (AACC, 2000). The extent to which the dough piece spreads during baking, i.e. cookie diameter, is a major parameter measured. Significant differences occur in the spread potential of different soft flour varieties. The effects of ingredients and flour components on final cookie diameter have been studied extensively (Curley and Hoseney 1984, Doecher et al. 1987, Yamazaki, 1959). Abboud et al. (1985).

Cookie spread rate appears to be controlled by dough viscosity (Abboud et al. 1985, Hoseney and Rogers 1994, Hoseney et al. 1988). Because gravity and the amount of leavening are constant, the flow of the dough is controlled by the viscosity. As the temperature of the dough increased, the apparent viscosity decreased. The cookie apparently expanded until the viscosity suddenly increased, as shown by Yamazaki (1959) using a vibratory viscometer. He suggested that changes in the limited quantity of water present and intensive competition for the water among the various flour components may contribute materially to cookie quality. Miller and Hoseney (1997) measured the extensional viscosity of cookie dough, and they related viscosity to cookie diameter. Lubricated squeezing flow was able to discriminate viscosities of doughs from different soft wheat cultivars. Doughs with lower viscosity cause cookies to spread at a faster rate (Hoseney and Rogers 1994, Hoseney et al. 1988).

Germinated sesame flour supplemented cookies had better nutritional quality as a result of increased protein content and lysine content derived from sesame flour; theycould also serve as a vehicle for increasing intake of protein and fat (Olagunju and Ifesan 2013). However, there is lack of information in literature about the effects of different flours like a.g. chestnut flour, pulse or sprout flours on rheological properties of cookie dough and on quality parameters of gluten-free cookies.

2 Aim of the Thesis

The aim of the work is to test the possibility of cookies production with graduated proportions of different buckwheat flours from sprouts and evaluate their selected qualitative properties.

3 Material and Methods

Material

The sample of common buckwheat (*Fagopyrum esculenthum* Moench) achenes (500g) from organic farming were cleaned and freed from foreign and mechanically dehulled. Composition: Fat 1.6 g, Carbohydrates 46 g, Fiber, 25 g, Protein 11 g.

Wheat flour (Předměřická mouka pšeničná, světlá hladká pečivárenská) was purchased from Mlýny J.Voženílek, spol. s r. o. Composition: Fats 1.5 g, of which - saturated fatty acids 0.3 g, Carbohydrates 70.0 g, of which - sugars 2.0 g, Protein 12.0 g, Humidity max. 15.0, Ash in dry matter max. 0.65 %, Wet gluten in dry matter, min. 24.0 %, Granulation, under 257 µm min. 96.0 %, under 160 µm min. 75.0%, Falling number 180 s.

Sprouts Preparation

For buckwheat sprout production, seeds surface-sterilized with UV rays. The seeds were directly placed into 30×45 cm plastic trays with two foils of filter paper saturated with sterile water. The germinating systems were incubated at 25±1°C under dark conditions. The seedlings were sprayed daily. Achenes were germinated for 96 hours. The plant material was weighted and dried in ventilated oven at 45±1°C for 48 h.

Blends Formulation and Preparation of Cookies

For the production of cookies, sprouts were ground into flour. Blends of wheat flour and buckwheat sprout flours containing 0%, 5%, 10%, 15% and 20% buckwheat sprouts flour (BSF), on a replacement basis, were prepared. The choice of these levels was based on the report of Dreuiter (1978) that the maximum level of wheat flour substitution by wheat sprouts that would produce an acceptable baked product was 25%. They were then packed in polyethylene bags, sealed and stored in a freezer (0–5°C) until required.Cookies were prepared according to McWatters et al. (2003) with slight modifications.
The basic ingredients used: 380 g of flour blend, 100 g vegetable oil, 225 g of granulated sugar, 21 g of beaten whole egg, 3.75 g of salt, and 1.8 g of baking powder.

The dry ingredients were weighed and mixed thoroughly in a bowl by hand for 3–5 min. Oil was added and rubbed in until uniform. The egg was added and dough was thoroughly kneaded by hand for 5 min. The dough was rolled thinly on a sheeting board to a uniform thickness (5 mm) and cut out using a round scorn cutter to a diameter of 35 mm. The cut out dough pieces were baked on an enamel plate at 160°C for 15 min in a baking oven.

Flour Characteristics

Water Absorption Capacity (WAC)

The method of Onwuka (2005) was used for the determination of WAC. Flour blends (1 g) was weighed into a 15 ml centrifuge tube and suspended in 10 ml of water. It was shaken on a platform tube rocker for 1 min at room temperature. The sample was allowed to stand for 30 min and centrifuged at 1,200 rpm for 30 min. The volume of free water was read directly from the centrifuge tube.

$$\text{WAC}(\%) = \frac{\text{Amount of water added} - \text{Free water}}{\text{Weight of sample}} \times \text{density of water} \times 100$$

Oil Absorption Capacity (OAC)

The method of Onwuka (2005) was used for the determination of OAC by mixing flour blends (1 g) with 10 ml sunflower oil in a centrifuge tube and allowed to stand at room temperature (23 ± 1°C) for 1 hr. It was centrifuged at 1,500 rpm for 20 min. The volume of free oil was recorded and decanted. OAC was expressed as ml of oil bound by100 g dried flour.

$$(\text{OAC}\%) = \frac{\text{Amount of oil added} - \text{Free oil}}{\text{Weight of sample}} \times \text{density of corn oil} \times 100$$

Bulk Density

The bulk density of the flour blends was determined using the method described by Onwuka (2005). About 10 g of the sample was weighed into a 50 ml graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top 10× from a height in ml. The volume of the sample was recorded.

$$\text{Bulk density}(\text{g/ ml}) = \frac{\text{Weight of sample}}{\text{Volume of sample after tapping}}$$

Foaming Capacity and Foaming Stability

Foaming capacity (FC) was determined according to the method described by Onwuka (2005). Flour blends (2 g) was weighed and added to 50 ml distilled water in a 100 ml measuring cylinder. The suspension was mixed and shaken adequately to foam, and the total volume after 30 s was recorded. The percentage increase in volume after 30 s is expressed as foaming capacity. The volume of foam was recorded 1 hr after whipping to determine foam stability as per the percent of initial foam volume.

$$(\text{Foaming capacity}\%) = \frac{\text{Volume after whipping} - \text{Volume before whipping}}{\text{Volume after whipping}} \times 100$$

Foaming stability % = Foam volume after 1 hour / Initial foam volume X 100

Swelling Capacity

The swelling capacity of flour blends was determined using a graduated cylinder of 100 ml filled with the sample to 10 ml mark. The distilled water was added to give a total volume of 50 ml. The top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. After 2 min, inverted suspension left to stand for a further 8 min, and the volume occupied by the sample was taken after the 8th min (Okaka and Potter 1977).

Physical and Sensory Characteristics

Diameter

Diameter of the cookies was determined using Vernier calipers. The technique for measurement is to first read the main scale to the nearest division and then the Vernier scale to measure the distance between the two main scale divisions which provide more accurate measurements. Diameter of the cookies was measured at least on five replicates and mean values recorded.

Thickness

Height (H) of cookies in terms of a millimeter (mm) were measured with the help of vernier caliper having at least count 0.01. The diameter and thickness of cookies were calculated as per AACC (2000) methods. Height of the cookies was measured at least on five replicates and mean values recorded.

Spread Ratio and Spread Factor

The spread ratio (SR) of the cookie was calculated by dividing the diameter of the baked cookie (D) by the height of the cookie (H).

As per the AACC (2000) method, the spread ratio of the control sample was considered to be standard (100%) and the spread factor of other samples of cookies was determined in comparison with the standard value. It was expressed in terms of percentage. Spread factor (SF) was determined using the formula: (Spread ratio of control/ Spread ratio of experimental)×100.

Weight

Weight of cookies were measured at least on five replicates and mean values recorded.

Hardness

The hardness of cookies was measured using Texturometer according to Giri and Sakhale (2021). A compression test was employed. The conditions employed were as follows: Pretest speed: 1.0 mm/s, test speed: 3.0 mm/s, posttest speed: 10 mm/s distance: 5 mm, and trigger force: Auto 50 g. The probe used for measurement of hardness was knife-edge with slotted insert (HDP/BS). The maximum force required just to break the cookies is the hardness. It was expressed in terms of Newton (N). The hardness of the cookies was measured at least on five replicates and mean values recorded.

Color

A colorimeter was used to measure the color of the cookies. This device allows the expression of color in the CIELab color space. Lighting mode D 65 was used for colorimetric determination.

A standard white board (100% reflectance) was used for setting the instrument.

Color of the cookies was measured at least on five replicates and mean values recorded.

CIELab scales:

L * (Lightness) measure of color brightness,
a * - representation of red (+) or green (-) color,
b * - representation of yellow (+) or blue (-) color.
h – Hue - color shade (dominant wavelength)
Formula for calculating color shades

$$h^0 = tan^{-1}\left(\frac{a^*}{b^*}\right)$$

C * - Chroma: saturation Formula for calculating

$$Cab = \sqrt{a^2 + b^2}$$

Sensory Characteristics

Cookies were evaluated for color and appereance, flavour, taste, texture and overall acceptability. Sensory characteristics of cookies was carried out by a group of 10 panelists. Judges participated in the sensory evaluation of the cookies on a 9-Point Hedonic Scale:

Like Extremely
Like Very Much
Like Moderately
Like Slightly
Neither Like nor Dislike
Dislike Slightly
Dislike Moderately
Dislike Very Much
Dislike Extremely

The coded cookie samples were randomized and presented to the judges on white plates. The samples were presented with code numbers in a random order to the panelist and were asked to score for various sensory attributes.

Statistical Analysis

The influence of buckwheat flour portion in cookies on selected parameters was evaluated by analysis of variance with the post hoc Tukey HSD test in program Statistica 12.0.

4 Results

Flour Characteristics

Table 4.1: Mean flour characteristics of cookies with different portion of buckwheat sprout flour (BSF). Different small letters (a–b) indicate significant differences.

Portion of BSF	WAC	Swelling	Foaming	Stability	Bulk density	OAC
%	ml	ml	%	%	g/ml	%
0	124.6a	7.5a	27.5a	15.6a	0.6667	91.7
5	199.4ab	8.0a	47.2b	15.0a	0.6658	91.7
10	249.3ab	8.0a	31.4ab	30.4b	0.6667	137.6
15	249.3ab	11.0b	26.4a	27.5ab	0.6458	183.4
20	324.0c	11.5b	22.6a	20.0ab	0.6351	183.4

BSF – Buckwheat Ssprouts in Flour, WAC – Water Absorption Capacity, OAC- Oil Absorption Capacity,

Water absorption capacity (WAC): Water absorption capacity of different variants of flour was at highest with 324.0 ml for variants with 20% share of buckwheat sprouts and at lowest with 124.6 ml for the control variant (Table 4.1). There was a statistically significant difference between these two variants. So, addition of buckwheat sprouts in wheat flour for cookies production significantly increased WAC.

Swelling: The swelling capacity of the different flour variants was at highest with 11.5 ml for the variant with 20% share of buckwheat sprouts and at lowest with 7.5ml for the control variant. There was a statistically significant difference between flours with 0, 5 and 10% buckwheat sprouts and flours with 15 and 20% buckwheat sprouts. So, addition of buckwheat sprouts to wheat flour for production of cookies increased the swelling capacity.

Foaming: The foaming of different flour variants was the highest with 47.2% for the variants with 5% of buckwheat sprouts and at lowest with 22.6% for the variant with 20% of buckwheat sprouts (Table 4.1). The flour variants with 5 and 10% buckwheat sprouts were statistically different from other variants. Adding a higher proportion of buckwheat sprouts to wheat flour for cookies production did not reduce foaming.

Foaming stability: The foaming stability of the different flour variants was at highest with 30.4% for the variant with 10% share of buckwheat sprouts and at lowest with 15.0% for the variant with a 5% share of buckwheat sprouts. There was a statistically significant difference between flours with 0 and 5% buckwheat sprouts and flour with 10% buckwheat sprouts. Adding a higher percentage of buckwheat sprouts (15 and 20%) to wheat flour in cookies production again reduce foam stability.

Bulk density: The bulk density of different variants of flour was at highest with 0.6667 for the variant with 0% share of buckwheat sprouts and at lowest with 0.63551 for variant with 20% share of buckwheat sprouts. There was no statistically significant difference between variants from 0% up to 20% share of buckwheat sprouts. From this point of view, the addition of buckwheat sprouts to wheat flour can therefore be recommended for the production of cookies.

Oil absorption capacity (OAC): The OAC of different variants of flour was at highest with 183.4 for variant with 20% share of buckwheat sprouts and at lowest with 91.7 for variant with 0% share of buckwheat sprouts. However, there was no statistically significant difference between variants from 0% up to 20% share of buckwheat sprouts. So, the addition of buckwheat sprouts for cookies production in wheat flour can be recommended. OAC has great importance since fat acts as flavor retainer and also increases soft texture to mouth feel of foods.

Physical Characteristics of Cookies

Table 4.2: Physical characteristics of cookies with different portion of buckwheat sprout flour (BSF) (average ± standard deviation). Different small letters (a–b) indicate significant differences.

Portion of BSF %	Diameter mm	Weight g	Height mm	SR	SF %	Hardness N
0	37.67±1.25	7.76±0.558a	8.53±0.100a	4.42	100.0	118.9±37.4b
5	37.74±1.50	7.63±0.699a	8.50±0.113a	4.44	100.5	85.8±35.9ab
10	37.38±6.99	7.89±0.143b	8.46±0.117a	4.42	100.0	83.0±27.0ab
15	38.20±4.69	8.56±0.103b	9.37±0.055b	4.08	92.3	80.6±27.3ab
20	38.20±6.71	8.24±0.629b	9.25±0.548b	4.13	93.5	68.2±41.1a

BSF – Buckwheat sprouts in flour, SR- Spread Ratio, SF – Spread Ffactor

Diameter: The diameter of cookies with different variants of flour was at highest with 38.20 mm for variant with 20% share of buckwheat sprouts and at lowest with 37.67 mm for variants with 0% share of buckwheat sprouts (Table 4.2). However, there was no statistically significant difference among variants of flours from 0% up to 20%

share of buckwheat sprouts. The addition of buckwheat sprouts to wheat flour for cookies production can be recommended from this point of view.

Weight: The weight of the cookies was the highest with 8.56 g for the variant with 15% share of buckwheat sprouts and the lowest with 7.63 g for the variant with 5% share of buckwheat sprouts. Cookies made from flour with 10, 15 and 20% share of buckwheat sprouts were statistically significant different from cookies produced from flour with 0 and 5% share of buckwheat sprouts.

Height: The height of the cookies was the highest with 9.37 mm for the variant with 15% share of buckwheat sprouts and the lowest with 8.50 mm for the variant with 5% share of buckwheat sprouts. However, cookies made from flour with 0, 5, 10% share of buckwheat sprouts were statistically significant different from cookies made from flour with 15 and 20% share of buckwheat sprouts. Therefore, a higher addition of buckwheat sprouts to the cookies increased the height of the cookies.

Spread Ration (SR): The spread ration of different flour variants was the highest with 4.44 for the variant with 5% share of buckwheat sprouts and the lowest with 4.08 for the variant with 15% share of buckwheat sprouts. Addition of more portion of buckwheat sprouts (15 and 20%) to wheat flour in cookies production reduced the spread ratio.

Spread Factor (SF): The spread factor of different variants of flour was the highest with 100.5 for the variants with 5% share of buckwheat sprouts and the lowest with 92.3% for the variant with 15% share of buckwheat sprouts. There was a statistically significant difference between flours with 0, 5, and 10% buckwheat sprouts and flour with 15 and 20% buckwheat. Addition of more portion of buckwheat sprouts to wheat flour reduced the spread factor of the cookies.

Hardness: The hardness of the cookies was the highest with 118.9 N for the variant with 0% share of buckwheat sprouts and the lowest with 68.2 N for the variant with 20% share of buckwheat sprouts. There was a statistically significant difference between cookie variants with 20% and 0% share of buckwheat sprouts. So, the addition of a higher percentage of buckwheat sprouts reduced the hardness of the cookies.

Color Characteristics of Cookies

Table 4.3: Mean color characteristics of cookies with different portion of buckwheat sprout flour (BSF). Different small letters (a–b) indicate significant differences.

Portion of BSF (%)	L	a	b	Cab	h
0	9.9a	11.7	33.7b	0.335	36
5	15.7ab	7.5	14.5a	0.480	16
10	16.7ab	8.0	15.6a	0.476	18
15	19.6b	10.3	18.7ab	0.502	21
20	21.0b	13.0	17.9ab	0.629	22

BSF – buckwheat sprouts in flour

Lightness (L): The lightness of the cookies was the highest with 21.0 for the variant with 20% share of buckwheat sprouts and the lowest with 9.9 for the variants with 0% buckwheat sprouts (Table 4.3). The cookies with 20 and 15% share of buckwheat sprouts were statistically significant different from the control variant (0%). Addition of a higher percentage of buckwheat sprouts increased the lightness value of the cookies color.

The a*: The a* value was the highest with 13.0 for the variant of cookies with of cookies with 20% share of buckwheat sprouts and the lowest with 7.5 for the variant with 5% share of buckwheat sprouts. There was no statistically significant difference among the variants of cookies. The addition of buckwheat sprouts to the cookies did not cause a change in this color parameter.

The b*: The b* value was the highest with 33.7 for the variant of cookies with 0% share of buckwheat sprouts and the lowest with 14.5 for the variant with 5% share of buckwheat sprouts. The cookies made from flour with 5 and 10% share of buckwheat sprouts were statistically significant different from other variants of cookies. A higher addition of buckwheat sprouts did not increase the value of the b* color parameter in cookies to a level similar to the control variant.

The Cab: Cab value was the highest with 0.629 for the variant of cookies with 20% share of buckwheat sprout and the lowest with 0.335 for the variant with 0% buckwheat sprouts. The addition of buckwheat sprouts increased the value of Cab.

The h: h value was the highest with 36 for the variant with 0% buckwheat sprouts of cookies and the lowest with 16 for the variant of cookies with 5% share of buckwheat sprouts. A higher percentage of buckwheat sprouts, the value of h increased.

Sensory Characteristics of Cookies

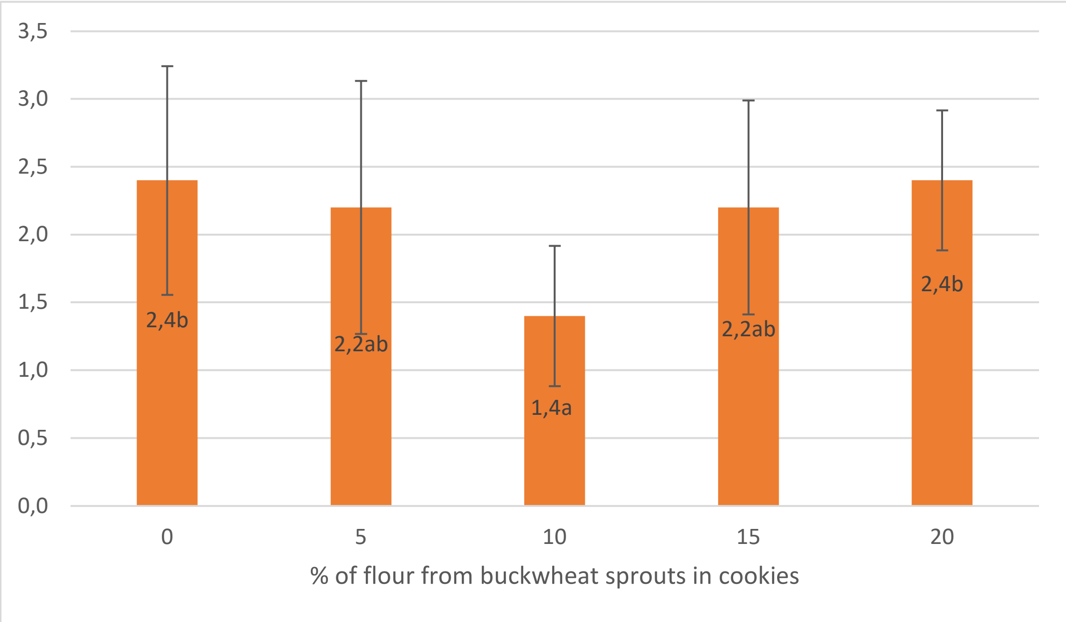

Figure 4.1: Sensory evaluation of color and appereance of cookies on a 9-Point Hedonic Scale (average ± standard deviation). Different small letters (a–b) indicate significant differences.

Color and appearance: Color and Appearance we can see that the best rating for color and appearance, i.e. the lowest value (1.4) is for cookies with a 10% share of buckwheat sprouts (Figure 4.1). This variant of cookies was statistically different from the control variant and the variant with 20% addition of buckwheat sprouts. Therefore, the control cookies without the addition of buckwheat sprouts and with the addition of 20% were rated the worst with an average value of 2.4. It can therefore be concluded that the addition of buckwheat did not negatively affect the color and appearance of the evaluated cookies. And from the point of view of color and appearance of cookies, 10% addition of buckwheat sprouts can be clearly recommended.

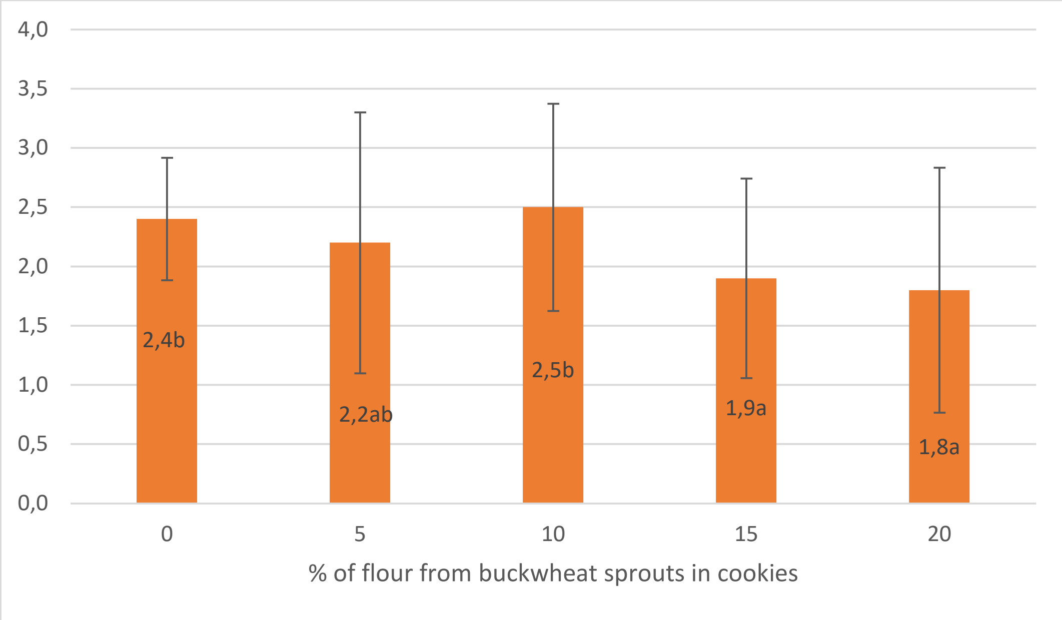

Figure 4.2: Sensory evaluation of texture of cookies on a 9-Point Hedonic Scale (average ± standard deviation). Different small letters (a–b) indicate significant differences.

Texture: The texture of the cookies was best rated for the variants with 15% and 20% share of buckwheat sprouts (1.9 for biscuit with 15% and 1.8 for cookies with 20% share of buckwheat sprouts respectively).These two types of cookies did not differ from each other in a statistically significant way, and the addition of buckwheat sprout therefore did not have a negative effect on the texture of the cookies (Figure 4.2). The addition of buckwheat sprouts in a proportion of up to 20% can be recommended.

Flavour: The flavour of cookies was best rated for the variants with 0-15% share of buckwheat sprouts with the value of sensory evaluation from 2.4 to 2.8 on the average. The variant with 20% share of buckwheat sprouts had the highest value of sensory evaluation (3.2). This variant of cookies was statistically different from other variants (Figure 4.3). Therefore, the addition of buckwheat sprout negatively affected the flavour of cookies. 20% addition buckwheat sprouts in cookies created an advantage their worse flavour, and from this point of view, the 20% share buckwheat sprouts in cookies cannot be recommended.

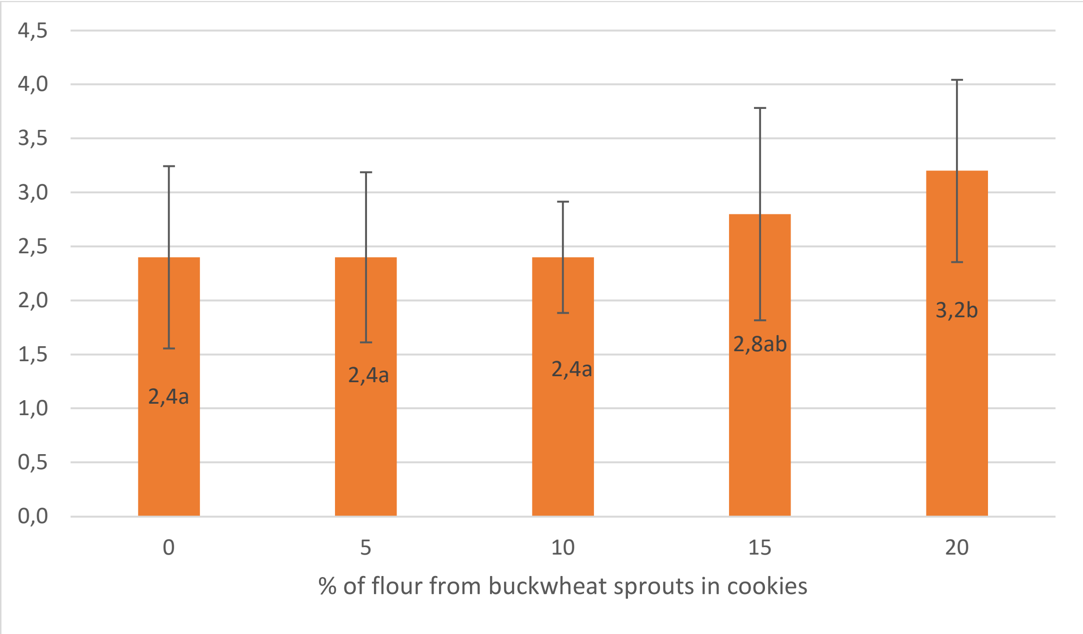

Figure 4.3: Sensory evaluation of flavor of cookies on a 9-Point Hedonic Scale (average ± standard deviation). Different small letters (a–b) indicate significant differences.

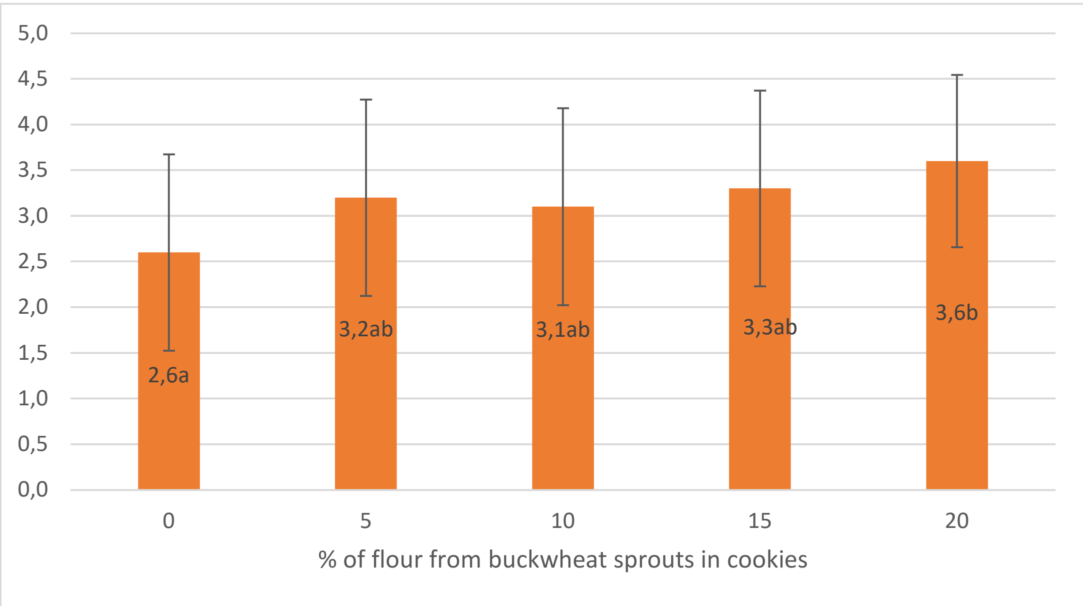

Figure 4.4: Sensory evaluation of taste of cookies on a 9-Point Hedonic Scale (average ± standard deviation). Different small letters (a–b) indicate significant differences.

Taste: The taste of cookies was best rated (2.6) for the variant with 0% share of buckwheat sprouts (Figure 4.4). This variant was statistically significantly different only from variant with 20% share of buckwheat sprouts. The addition of buckwheat sprouts in 20% share negatively affected the taste of the cookies. Therefore the share of buckwheat sprouts up to 15% can be clearly recommended.

Overal acceptability: The overall acceptability of the cookies was evealuted the best for the variants with 5% and 10% share of buckwheat sprouts (2.8 for cookies with 5% and 2.6 for cookies with 10% share of buckwheat respectively). However, the difference between the diffrence cookies variants were not statistically significant Figure 4.5). The addition of buckwheat sprouts in a proportion of up to 20% did not affect negatively the overal acceptability of cookies and the addition of buckwheat sprouts up 20% can be recommended.

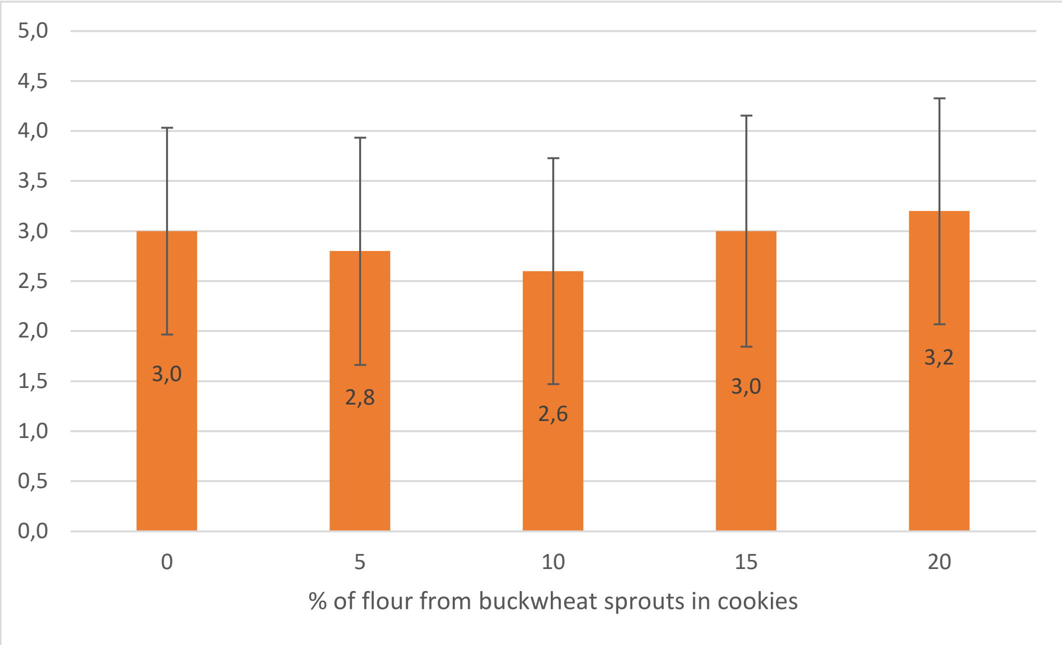

Figure 4.5: Sensory evaluation of overal acceptability of cookies on a 9-Point Hedonic Scale (average ± standard deviation). Different small letters (a–b) indicate significant differences.

5 Discussion

Food products manufactured with sprouts flours have attracted widespread interest in recent years, due to their high nutritional values with various health benefits, becoming more and more. The addition of buckwheat sprouts were added and used for food processing to improve quality and functionality of food (Lee and Kim, 2008).

According to Sturza et al. (2020), by adding the buckwheat sprouts flour in wheat flour, the nutritional quality of buns has been significantly improved in terms of starch digestibility, phenolic content, total flavonoid content and antioxidant activity.Buckwheat sprouts have been tried and use by products, namely wheat buns or noodles (Sturza et al., 2020, Kim et al. 2005).

Flour Characteristics

Based on our results, the water absorption capacity of flour prepared for the production of cookies increased significantly when it was fortified with buckwheat sprouts in a proportion from 5 to 20%. The water absorption capacity also significantly increased in germinated sorghum flour (Ojha et al. 2018). Water absorption of the flour depends upon availability of polar amino acids in flours and association of amylose and amylopectin in the granules of starch. The increase in WAC by germination is probably caused by to the breakdown of starch and an increase in protein level, which probably increased the sites for interaction with water molecule (Lorenz and Collins 1990). The high water absorption capacity of flour, makes it a useful ingredient in food products like soups, beverages, and baked products (Sirivongpaisal 2008).

Bulk density is heaviness of the flour that is affected by surface properties individual particles. Based on our own result, the bulk density of different flour variants was not different from the control variant – the wheat flour, therefore addition of buckwheat sprouts in wheat flour can be favourably recommended. While the bulk density of sprouted mungbean decreased after sprouting (Liu et al. 2018). Reduction in bulk density of was also descriebed by malted sorghum flour (Ojha et al. 2018). According to Oti and Akobundu (2008) break down of starch during germination reduce starch content and decrease the bulk density

According to our result, the addition of buckwheat sprouts to wheat flour in production of cookies increased the swelling capacity. Similarly, addition of sprouted mungbean and malted sorghum to wheat flour in making cookies increased the swelling capacity/ index. (Offia –Olua Blessing and Akubuo Kingsley 2019).

Color Characteristics of Cookies

Noodles mixed, with 2 to 4% of buckwheat sprout powder increased yellowness and redness, lightness decreased (Kim et al, 2005). On the other hand, according to our obtained results, the value of yellowness (b*) of cookies increased by adding buckwheat sprouts (5-20%). The addition of buckwheat sprouts to the cookies had no significant effect on the redness value (a*) of the cookies. The lightness (L) of the cookies increased with the addition of a higher percentage of buckwheat sprouts.

Physical Characteristics of Cookies

Noodles mixed, with 2 to 4% of buckwheat sprout powder improve significantly texture such as hardness, chewiness and gumminess. The weight of noodles mixed, with 2 to 4% of buckwheat sprout powder was decreased (Kim et al, 2005). The volume was not affected (Kim et al. 2005). Based on the obtained results, we can state that the hardness of the cookies was reduced by adding buckwheat sprouts (5-20%). The volume of cookies was not affected by the addition of buckwheat sprouts (5-20%).

Contrary to Sturza et al. (2020) found that wheat flour could be successfully replaced by 10% buckwheat sprouts flours in wheat buns, without negative influence on texture parameters.

Sensory Characteristics of Cookies

According to our results, it is possible to replace wheat flour in cookies with buckwheat sprouts up to 15%, without affecting the sensory characteristics of cookies parameters. Contrary to Sturza et al. (2020) found that wheat flour could be successfully replaced by 10% buckwheat sprouts flours in wheat buns, respectively, improving their nutritional value, without negative influence on sensorial features. In noodles, Kim et al, (2005) found suitable portion of buckwheat sprouts only 4%. Bae et al. (2014) gives a suitable substitution wheat flour in bread by non-wheat flours from millet, sorghum, sweet potatoes in the range of 10-30%

A higher proportion of sprouts of other crops in wheat flour in the production of cookies than in our case is reported by Offia-Olua Blessing and Akubuo Kingsley (2019).

Cookies made with 65% sprouted mungbean (*Vigna radiata*) or 35% malted sorghum flour (*Sorghum bicolor* (L) Moench) was favourable compare with the control (Offia-Olua Blessing and Akubuo Kingsley 2019).

6 Conclusions

- Only the addition of buckwheat sprouts in 20% share to wheat flour for cookies production significantly increased the water absorption capacity.
- When of buckwheat sprouts were added in 15 and 20% share to wheat flour for cookies production, there was an increase in the swelling capacity.
- A higher portion of buckwheat sprouts (15 and 20%) to wheat flour for cookies production did not significanly influence oil absorption capacity, foaming and foaming stability of the flour.
- A higher proportion of buckwheat sprouts (15 and 20%) to wheat flour for candy production did not significantly affect the oil absorption capacity, foamability and foam stability of the flour.
- The addition of buckwheat sprouts for cookies production to wheat flour can therefore be recommended in terms of the flour properties.
- The addition of buckwheat sprouts from 0% up to 20% share in wheat flour did not have significant influence on the diameter of cookies.
- Higher addition of buckwheat sprouts (15 and 20%) to wheat flour increased the weight, and height of the cookies, and decreased the spread ratio and spread factor of the cookies.
- The addition of 20% share of buckwheat sprouts reduced the hardness of the cookies.
- The addition of a higher percentage of buckwheat sprouts (15 a 20%) to wheat flour increased the lightness value of the cookies color.
- From other color parameters, the addition of buckwheat sprouts gradually increased the color value of Cab and decreased the value of h.
- From sensory characteristics of cookies, the addition of buckwheat sprouts did not negatively affect the color and appearance, texture and overal acceptability of cookies.

- Only the addition of buckwheat sprouts in 20% share % had a negative effect on the taste and flavour of the cookies.

- For the production of cookies, we can therefore recommend the addition of buckwheat sprouts to wheat flour up to 15%.

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List of abbreviations

BSF -Buckwheat Sprouts Flour

WAC - Water Absorption Capacity (WAC)

OAC - Oil Absorption Capacity (OAC)

FC -Foaming Capacity

D - Diameter of the Cookies

H - Height of cookies

SR - Spread Ratio (SR)

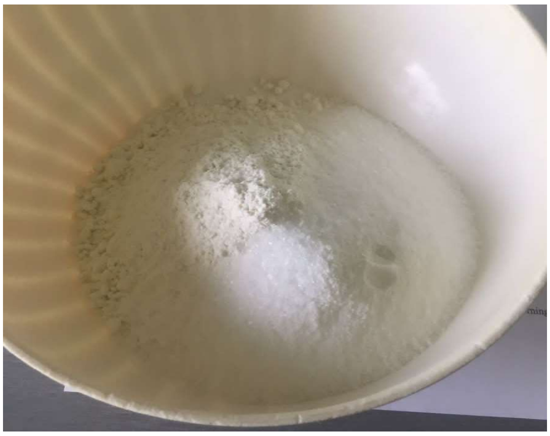
SF -Spread Factor (SF)

L - Lightness

Image Attachment

Dried sprouts prepared for flour preparation

Foaming capacity determination



Dough preparation

Cookies preparation