

Study of Wheat Growth Processes

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Abstract— The aim of the work is to select the most common soft and hard Kazakhstan wheat varieties in the grain industry, to study and refine the germination regimes, to analyze the chemical composition and biological activity of germinated grains. The experiment was conducted in the Problem Research Laboratory for the creation of new generation food products at the Almaty Technological University. 6 Kazakhstan wheat varieties were studied, which were germinated for 4-5 days. Further, analyzes were carried out on the content of vitamins, nutrients and ash. Based on the studies and experimental data obtained, it was established that the nutritional value of wheat germ is due to high extractivities, the presence of dietary fiber, high vitamin and enzymatic activity. It is shown that the germination of grain is accompanied by a significant increase in the antioxidant capacity of the grain.

Index Terms— nutrition, wheat, germinated seed.

I. INTRODUCTION

Nutrition is one of the most important and reliable ways to improve health, regulate vital activity, prevent and cure chronic degenerative diseases.

A significant part of the diet consists of seeds - these are cereals, legumes and others. Seeds in their composition in significant quantities contain "building material" for future plants: mainly starch, proteins and fats.

Wheat is the oldest and one of the most important cereal crops in the world and its presence is ubiquitous in the food cultures of many different regions of the world. The wheat grain provides for much of the world's dietary protein and food supply; in particular, the products of whole wheat retain the complete nutrition of the whole grain. A sufficient consumption of the whole grain products has a positive influence on the human cardiovascular system and is considered to protect against affliction from certain types of cancers [1].

Although wheat grain may be used as a whole in different ways in the preparation of food for humans yet it is usually pulverized and fractionated during the preparation for further processing. The modern process of milling of wheat is highly complicated, because several grinding stages are required to obtain a patent flour, which does not contain any bran or germ. During the reduction in size of the grain, both the grinding methods and the properties of the material affect the breakage of the particle and the energy requirements for the grinding process. This process entails the use of a wide range of

equipment. However, the cereal industry uses roller mills and hammer mills. Hammer mills can effectively process high-fiber components present in the kernel and thus, are commonly used in the feed industry, however, they can also be effectively used in the production of the whole grain flour [2].

Among all the properties of the wheat kernel, its mechanical properties have the most significant influence on the grinding process. These properties are further affected by many factors, such as, genetic heritage, the conditions required for, the water content of the kernel, and the temperature conditions [3-7].

Sprouted seeds can be attributed to functional foods that are capable of providing a healthy effect, both on the state of the gastrointestinal tract, and on the body as a whole. Inclusion of seedlings in the diet replenishes the body with three groups of substances. These are enzymes, antioxidants and polysaccharides (food fiber's and pectin's). They are necessary for the normalization of metabolism, enhance immunity, effective digestion, normalize weight, slow the maturing process. These substances are contained in maximum quantities in germinating seeds [8].

One of the main properties of seedlings is their ability to synthesize water-soluble vitamin C, while in dry seeds it is not detected. Within one plant species the amount of synthesized ascorbic acid depends on the variety used [9].

In addition to vitamin C sprouts of various cultures are a source of vitamins A, B, E, folic acid. In sprouted wheat, the content of vitamin C and B₆ after germination increases 5 times, vitamin B₁ – more than 1.5 times, B₂ – 13.5 times, folic acid – 4 times, vitamin E – 3 times. The concentration of natural antibiotics and growth promoters sharply increases [9].

During sprouting, sprouts absorb microelements and other minerals from the water that is used to germinate. Moreover, the mineral substances in the seedlings are chelated, that is, they are in the natural state - they are bound to amino acids and therefore are well absorbed by the human body [10].

It is known that sprouted grains of rice have specific healing properties and are recommended to people with diseases of the bladder and kidneys, increase lactation of nursing mothers, have a calming effect, restore appetite, can reduce the damage to blood vessels and nerves that have arisen in diabetes mellitus, normalize the digestive system, reduce blood pressure, blood sugar level, prevent flabbiness of the muscles, strengthen the heart muscle, reduce the risk of anemia. It is believed that with regular consumption under the influence of a variety of substances useful for human beings, as well as the energy of the germinating seed, the organism becomes healthy, and many of the ailments are delivered simultaneously [11,12].

The germinated grain is enriched with minerals, vitamins, amino acids, increased amounts of vitamins C

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and B, which have a positive effect on the functioning of the circulatory, cardiovascular systems, soothes nerves, rejuvenates the body and strengthens its protective properties.

The benefit of sprouted beans is also that the grain becomes a stimulant for the production of vitamin C, thereby protecting the body from the external negativity. The properties of the germinated bean grain perfectly restore the metabolism, control it and ensure further uninterrupted activity.

The addition of sprouted seeds into the diet stimulates metabolism and hematopoietic, increases immunity, compensates for vitamin and mineral insufficiency, normalizes the acid-base balance, promotes the purification of the organism from slags and intensive digestion, slows down the aging process [13].

The aim of the work is to select the most common soft and hard Kazakhstan wheat varieties in the grain industry, to study and refine the germination regimes, to analyze the chemical composition and biological activity of germinated grains.

II. MATERIALS AND METHODS

In Kazakhstan, a wide range of wheat varieties has been selected by breeders, taking into account the regions of the country, as they differ in climatic conditions, soil characteristics and fertility, adaptability to adverse environmental conditions, resistance to pests and diseases, etc. With the improvement of technology, the emergence of new technology, the first requirement to the cultivar cultivated in production, its adaptability to the concrete conditions of the macro- and microzones is considered. An important system of varieties has in the formation of the entire production process: the timing, stretch and tension of conducting spring field work, care of crops, harvesting campaign. It is very important that varieties allow to increase the optimal timing of all technological operations. The final requirement, combining all listed and many other advantages of the variety, should be its commercial competitiveness. Therefore, we selected solid and soft wheat varieties that have been designed and currently approved for use in production in Kazakhstan and the Russian Federation, distributed mainly in the southern regions of the country: soft varieties – Kazakhstan 4, 10, Zhenis, Aray; solid varieties – Serke, Lan, Salauat.

Initially, wheat grains were sorted by sorts, sorted, cleaned of metal impurities, from mechanical and organic impurities, first washed with warm water at a temperature of 20–25 °C several times until the washing water became clean, the final washer was pasteurized, chilled to 10–12 °C with water. Then the wheat was soaked in a stainless or enameled container with a flat bottom by adding pre-boiled or pasteurized water, cooled to 30–35 °C to a water level within 3 cm above the surface of wheat grains. The room temperature was 22 °C and humidity 72–76 %. It was kept in this state for 24 hours, then the water was drained, leaving about 1–2 cm of water at the bottom of the container under wheat grains. Every day during the experiment (the optimum germination time was selected for 5 days), the contents of the container were gently mixed and the surface of the grains was moistened with a spray gun for intensive growth of wheat

seedlings, then the seeds were sampled and the length of the seedlings was measured.

After 5 days, sprouted wheat grains were removed and dried at 22 °C for 24 hours to standard moisture of seedlings of wheat grains.

Traditional standard methods are used to definition of physical and chemical, biochemical properties of quality and safety of raw materials and production. Mass fraction was determined according to, antioxidant activity, mg/100 g, vitamins (water soluble, thiamin B₁, riboflavin B₂, pantothenic acid B₆, folic acid B₉, niacin PP) – the method of capillary electrophoresis on the device "Kapel–105M", (fat–soluble, tocopherol E) – method of high-performance liquid chromatography on the device "Agillent–1200"[14–16].

In order to determine fat–soluble, tocopherol E use the method high–performance liquid chromatography on the device "Agillent–1200".

Preparation of samples for measurements includes the following steps:

- alkaline hydrolysis of the product sample and extraction from the sample of vitamins;
- purification of the hydrolyzate and concentration of vitamins from the sample by solid-phase extraction;

Preparation of a sample for entering a chromatograph.

Two parallel samples are prepared for analysis.

For the chromatographic determination of fat–soluble vitamins A, E, and D₃, a gradient HPLC system with a spectrophotometric detector that allows the wavelength of the light source to be varied during the analysis and a column thermostat should be used.

For the analysis, calibration solutions A, E and D₃ are prepared; sample preparation is carried out; prepare the device for operation.

Equipment:

liquid chromatography "Stayer" with a spectrophotometric detector UVV 104.1M;

thermostat TS10;

personal computer with the installed software "MultiChrome" version 1.5 or 2x.

Conditions:

gradient separation mode;

mobile phase: acetonitrile (eluent A) -dichloromethane (eluent B);

gradient elution program:

beginning A = 100% B = 0%;

gradient A = 90% B = 10% for 8 min;

gradient A = 70% B = 30% in 2 minutes;

isocratic A = 70% B = 30% 10 min;

Gradient A = 100% B = 0% for 3 min;

isocratic A = 100% B = 0%

column: "Luna C18 (2)" 5 µm 250x4,6 mm (Phenomenex, USA);

protective column: "C18" 4x3.0 mm (Phenomenex, USA);

flow rate: 1.0 cm³ / min;

volume of the loop dispenser: 20 µl;

temperature: room;

detection: spectrophotometric when the wavelength of the light source is changed during the analysis

0 min is the wavelength of 436 nm,

10 min is a wavelength of 280 nm,

27 min is the wavelength of 436 nm.

Graduations in the entire range of measured concentrations are carried out at least once a month, as well as when changing columns and/or protective columns, when replacing substances and / or reagents; after the repair of the chromatograph, after a long period of inactivity of the chromatograph (2 weeks or more), with a change in the efficiency of the chromatographic system and/or the sensitivity of the detector.

To obtain the result of the measurements, two parallel samples are analyzed, for each of which two measurements are performed (two chromatograms are obtained). The mass concentration of the analyzed I component (vitamin A (retinol), vitamin E (α -tocopherol) and vitamin D₃ (cholecalciferol) in parallel samples introduced into the chromatograph (C_{i1}) and (C_{i2}) is automatically calculated by the chromatographic information.

If the mass concentration of the sample introduced into the chromatograph is greater than the upper limit of the calibration range (for vitamin A – 0,0200 mg/dm³, for vitamin E – 0,1500 g /dm³, for vitamin D₃ – 0,0150 g/dm³), The sample is diluted with isopropyl alcohol before being introduced into the chromatograph. The dilution factor is taken into account in the calculation.

The arithmetic mean of the mass concentration of the I-th component in the samples introduced into the chromatograph (C_{i1} and C_{i2}) is calculated from the results of two measurements for each of the parallel samples by formula

$$C_{i\text{md}} = (C_{i1} + C_{i2})/2 \quad (1)$$

The mass fraction of the i-th component in the analyzed sample X_i pr, [mg / kg] is calculated by the formula

$$X_i = \frac{C_{i\text{cp}} \cdot V_1 \cdot V_3 \cdot K_2}{K_1 \cdot m_{\text{rp}} \cdot V_2} \quad (2)$$

Where:

$C_{i\text{md}}$ – average value of the mass concentration of the I-th component in the sample, introduced into the chromatograph [g / dm³];

m_{pr} is the mass of the product sample, [g];

V_1 – volume of hydrolyzate [cm³];

V_2 – volume of hydrolyzate taken for analysis, before dilution with water ($V_2 = 8$ cm³);

V_3 is the volume of the eluate;

K_1 is a coefficient that takes into account the yield of the hydrolysis reaction and the degree of extraction of vitamins from the sample;

K_2 – the coefficient of difference in the preparation procedures for the analysis of calibration solutions and samples, calculated by the formula

$$K_2 = \frac{V_{\text{zp1}}}{V_1} \cdot \frac{V_{\text{zp3}}}{V_3} \quad (3)$$

Where:

V_{rp1} – volume of hydrolyzate of calibration solutions [cm³];

V_{rp3} – volume of eluate at TFE calibration solutions.

After the abbreviations, the calculation formula becomes:

$$X_i = \frac{C_{i\text{cp}} \cdot V_{\text{zp1}} \cdot V_{\text{zp3}}}{K_1 \cdot m_{\text{rp}} \cdot V_2} \quad (4)$$

For determine water soluble vitamins, we use method of capillary electrophoresis on the device "Kapel–105 M".

The main extractant for the investigated group of substances is purified water. However, the dissolution of some vitamins studied requires the creation of additional conditions. So, in the case of folic acid and biotin, a pH value was found at which the most optimal dissolution of the substance was observed. The following ranges of pH values were studied, starting at pH = 7.0 and ending with pH = 11.5 with a step of 0.5. The completeness of the extraction was checked by the method of the IEC.

It was found that the most optimal pH range for extraction of both vitamins 9.5–12.0 (the pH value was established by adding 0.1 M sodium hydroxide solution).

According to the literature, riboflavin is hardly soluble in water at room temperature and is slightly soluble in boiling water. For its extraction from the objects of the study, the sample weighed was placed in a volumetric flask and the extraction was carried out with water of a sample that was purified with heating in a water bath for 10–15 minutes.

Preparation of tableted and powdered sample forms: about 0.05–0.2 g (accurately weighed) of a thoroughly crushed sample was placed in a 50 ml volumetric flask, extracted with 30 ml of purified water (alkalized in the case of folic acid and biotin to pH = 9.5–12.0 on universal indicator paper), shaken vigorously on the shaker for 10 minutes, sounded on an ultrasonic bath for 5 minutes. For the best extraction of riboflavin, the sample was heated in a water bath for 10–15 minutes. Preparation of liquid sample forms (syrops, solutions for injections, drops, beverages): about 1 g (accurate sample) or 1 ml (exact volume) of the sample was placed in a 50 ml volumetric flask, extracted with 30 ml of purified water (alkalized in the case of folic acid to pH = 9.5–12.0 litmus), shaken vigorously on the shaker for 10 minutes. After this, in both cases, the volume of the sample solution was adjusted to the mark with purified water and mixed. The resulting solution was filtered through a membrane filter with a pore size of 0.45 μm or centrifuged at 20,000 g for 10 minutes. In the case where the sample contained folic acid, riboflavin, and other water-soluble vitamins, 3 samples of each sample were prepared (only in the case of tableted and powdered forms): separately with alkalization for the extraction of folic acid and biotin, separately with heating on a water bath for extraction of riboflavin and separately for the extraction of other water-soluble vitamins. The prepared samples were analyzed for 24 hours.

Also, the parameters of the separation of vitamins under the conditions of the developed procedure were compared with the HPLC method [17]. For this purpose, a solution of standard substances of water-soluble vitamins of the following composition was used: thiamine chloride, nicotinamide, nicotinic acid, pyridoxine hydrochloride and pantothenic acid. In Fig. 5 shows an example of the separation of vitamins by HPLC–technique.

III. RESULT AND DISCUSSION

On the side of durum wheat there are several advantages, depending on the physical and chemical properties of the grain. The first is the size of the starch grains. Here they are much smaller. The second is the grain size. It is smaller and easier to process. The third is gluten. Hard wheat is very rich in gluten (the dough absorbs a lot of water). Dough made

Study of Wheat Growth Processes

from hard grains is used when baking bread. But some special varieties go to the production of high-quality pasta. The best pasta is made from such special flour and water without adding anything else.

In order to formulate requirements for wheat germs

intended for use as an ingredient for food production, changes in wheat germination were investigated. With the germination of seeds, a germ grows, the length of which increases in proportion to the duration of germination (*Table 1*).

Table1. Change in the length of the sprout within five days

Variety of wheat	Length of germ, cm, in					Weight of wheat before drying, g
	1 day (24h)	2 day (48h)	3 day (72h)	4 day (96h)	5 day (120 h)	
Zhenis	0,9	1,9	2,6	4,0	4,2	369
Kazakhstan-10	0,8	1,3	2,0	2,0	1,92	329
Arai	0,9	1,6	3,2	4,0	3,72	349
Kazakhstan-4	1,0	1,9	2,9	3,0	3,2	336
Lan	0,9	1,7	2,7	3,4	3,4	475
Serke	0,7	1,6	2,5	3,0	4,2	385
Salauat	0,8	1,4	2,4	2,5	2,0	506

Germination of grain – the initial stage of the plant's life cycle. For seed germination, certain conditions are required – sufficient humidity, heat and air (oxygen). Germination begins with the absorption of the seed of moisture and swelling (average water content up to 50 % of the weight of the seed) [18-23]. The main feature of germination and its general biochemical orientation is the decomposition in the endosperm and cotyledons of high molecular substances to low molecular weight soluble substances with the

participation of moisture and under the action of enzymes. Another feature of germination is that if in the endosperm there are mainly hydrolytic processes, then in the embryo synthesis processes predominate [18-19, 24-27]. In the endosperm and sprouts of wheat during the first 5 days of germination, biosynthesis of protein disulfide reductase is observed, which leads to a continuous increase in its activity [28]. The change length, mass, moisture of the grain during germination can be traced on the example of wheat of Kazakhstan varieties (*Table 2, Figure 1, Figure 2*).

Table 2. Change length, mass, moisture of the grain during germination

Variety of wheat	Mass be-fore ger-minat ion,g	Moisture after washing, %	Length of sprout, cm, in				Mass before drying, g	Moisture before drying, %	Humidity after drying, %
			1 day (24h)	2 day (48h)	3 day (72h)	4 day (96h)			
Zhenic	200	33,7	0,62	0,82	1,22	1,65	338	31,5	11,2
Kazakhstan-10	200	33,3	0,72	0,75	0,82	1,15	352	31,5	8
Arai	200	32,3	0,75	0,83	1,00	1,33	323	31,7	8
Kazakhstan-4	200	32,8	0,85	1,03	1,35	1,50	293	32,7	9,1
Lan	200	33,3	0,77	0,83	0,90	1,38	378	32,5	8
Serke	200	32,9	0,77	0,93	1,55	2,63	334	31,2	8
Salauat	200	33,1	0,67	0,78	1,40	1,58	346	32,2	10,1
Cereals	Mass fraction, %					Proteins	Ash		
	Water	Fats	Carbohydrates						
Sprouted wheat	14-15	2,3-2,8	65-68			13-15	1,8-2,0		
Solid Hard	14,0	2,0	68,0			13,0-14,0	2,2		
soft	16,0	2,5	65,2			13,0-14,0	2,3		

Table3. Change in the chemical composition of the grain during germination

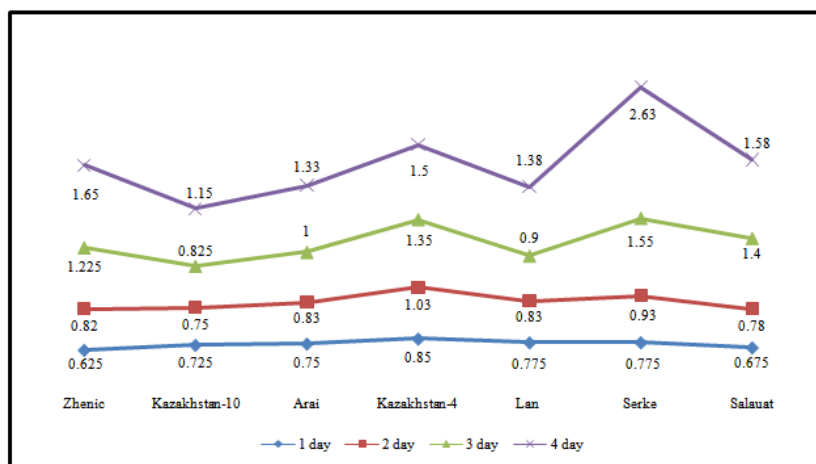


Figure 1. Length of sprout, cm

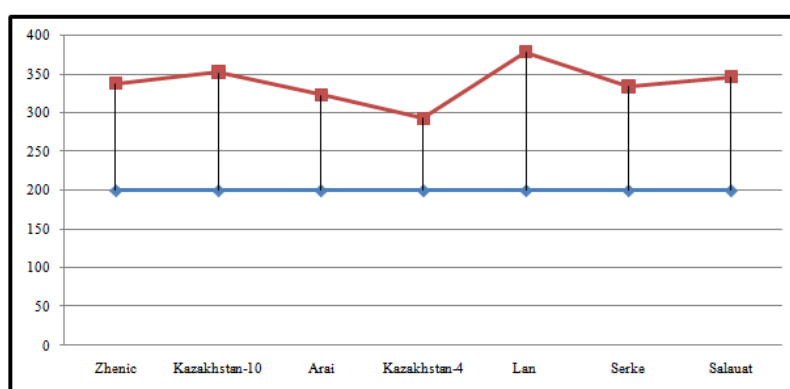


Figure 2. Mass before germination and drying, g

Table 4. Antioxidant activity of wheat germs

Wheat variety	Indicators, mass fraction					Antioxidant activity, mg/100 g
	Proteins, %	Fats, %	Ash, %	Moustore %, %	Carbohydrates in terms of dry matter, %	
Zhenic	7,07	0,97	1,21	24,75	52,01	7,9
Kazakhstan-10	5,91	0,93	1,03	7,23	54,45	14,1
Arai	6,34	1,52	1,50	17,03	46,24	11,5
Kazakhstan-4	5,95	1,22	1,09	10,55	57,39	48,2
Lan	6,39	1,82	1,37	12,71	53,67	21,6
Serke	5,19	2,02	1,29	9,68	55,33	20,2
Salauat	6,60	1,57	1,15	8,19	60,5	27,3

Table 5. Vitamin content in wheat grains and wheat germs (mg per 100 g)

Product	Vitamin					
	Water-soluble					Fat-soluble Tocopherol E
	Thiamine B ₁	Riboflavin B ₂	Pantothenic acid B ₅	Folic acid B ₉	Niacin PP	
Wheat grain	0,54-0,11	0,17-0,02	1,12-0,03	0,14-0,005	5,7-1,2	6,1
Wheat germ	0,23	0,3-1,45	0,7-3,0	0,3-0,7	3,4-7,5	15-30

Compared to whole grains, the embryo contains 50 times more vitamin E (tocopherol), the main antioxidant, which slows down the aging process, 10 times more vitamin B6 (pyridoxine), 3–4 times more vitamins F and P, in 2-3 times more protein compounds, 4–5 times more fat (Table 1). Researchers Maevskaya, Gudachevsky, 2001, Shatalova, 2004. Zverev, 2006, Shaskolskaya, who studied the processes of germination of grains, came to the same conclusions [29-30].

CONCLUSION

Based on the studies and experimental data obtained, it is established that the nutritional value of wheat germ is due to high extractivities, the presence of dietary fiber, high vitamin and enzymatic activity. It is shown that the germination of grain is accompanied by a significant increase in the antioxidant capacity of the grain.

We established the regularity of the optimal terms for the germination of wheat of hard and soft varieties (Zhenic, Kazakhstan-4, Kazakhstan-10, Arai, Lan, Serke, Salauat) a total duration 3 days. In this case, there is a significant increase in anti-oxidant properties, a rise in the content of vitamin (E, Folic acid), mineral composition (Fe, K, Mg, P) proves the increased biological value of germinated grains of crops.

In the future, research is planned on the development of food technology using sprouted grains of crops.

Use italics for emphasis; do not underline.

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