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THE TESTING OF NUTRITIONAL VALUES OF GERMINATED BEAN SEEDS IN DOMESTIC VARIETIES IN BOSNIA AND HERZEGOVINA

SUMMARY

The germination of seeds in cultivated plants is usually studied in terms of agricultural quality, but over the last few years, they have also been studied as possible sources of nutritional value as sprouts in diet. The sprouts of seeds in edible plants are recommended as dietary foods, since their nutritional content occurs in forms that are more acceptable to the human organism than in the case of raw beans.

The tests run under this research included three local varieties of beans: Bosna, Darko and Igman, where the properties of dry grain (grain size, grain weight) and sprouts (stage of development, germination time, sprout length, weight of seedlings) were determined. The absorption of water at the stage of swelling, the content of the dry matter, water, protein, carbohydrates (total sugars, starch) and fats, and their energy values were all determined as well.

The results of this research indicate that sprouts of commercial size may be produced in four days from seeds in the varieties Bosna and Igman, and in six days from seeds of the variety Darko. The ratio of weight between raw grains and sprouts differs among the varieties; hence 2.7 g of crude sprouts can be produced from 1 g of raw beans in the Bosna variety, 2.3 g from the Darko variety and 2.2 g from the Igman variety.

The nutritional value of sprouts, when compared to raw seeds for all three varieties, changed on average, where the dry matter content is lower in sprouted seeds the (up to 52.48%), as well as total sugar (up to 16.45%), starch (for 81.4%) and fat (up to 45.39%) content. The only exception is the protein content, which is higher by 29.0% in sprouted seeds.

Keywords: beans, seeds, weight, nutritional and energy values.

INTRODUCTION

The bean is an annual plant from the *Fabaceae* family, and *Phaseolus* genus, the seeds of which have a high nutritive value. It belongs to the group of grain leguminous plants seeds of which are traditionally acceptable foodstuff. Where its specific bio-chemical composition provides the main essential biological substances for normal growth, development and sustenance. The raw

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bean grain is rich in proteins and amino acids, which are very similar to meat proteins, and their digestibility (usability) is quite high. Furthermore, they are rich in hydrocarbons (starch, sugars, dietetic fibre) and lipids, and the content of minerals and vitamins are significant as well (Tepić, A. 2011.)

Over the past few years, many nutritionists have recommended using the sprouted seeds of edible plants in a healthy diet, including bean seeds. It has been pointed out that during the germination period, various metabolitic processes result in the transformation of nutritive matters into forms that are more acceptable for the human organism. By comparing the nutritive values of equal quantities of seeds, sprouts and vegetables in forms used as foodstuffs, it has been scientifically proven that sprouts have significantly higher share of vitamin C than in the case in seeds, even more than in the vegetables or cereals that they would grow into. The energetic value of sprouts is lower than in seeds, their share of proteins, vitamin B complex and iron are higher (Todorović, J.2008.).

There are many unofficial sources of information, which state that sprouts are an extremely valuable foodstuff that is becoming increasingly popular due to their nutritive values, medicinal properties and simple preparation. Furthermore, nutritionists call them vitamin-mineral bombs, because the quantities of minerals and vitamins increase by 4-10 times with germination when compared with the seeds before germination. Also, they contain enzymes and nucleic acids, which induce the exchange of substances, regenerate cells and boost up the immune system. They are easily digestible, so the usability of the vitamins and minerals that they contain is significantly higher than in the vitamin preparations obtained synthetically.

It is particularly underlined that bean sprouts are rich in proteins, ballast substances, promote digestion and the elimination of excess fluids, and they are also a tasty addition to salads, sauces and soups.

During germination, beans lose the unacceptable gas created during the digestion process, which reduces, to a large extent, its suitability in a diet. The research conducted shows that oligosaccharides are responsible for gas creation and that during the germination process the percentage of oligosaccharides is reduced by 90%. The bean sprouts contain a lot of fibre and water, so they are useful in solving obstipation problems.

In the production of sprouts as foodstuffs in a household, it is recommended to rinse seeds 3-4 times a day during the germination period. The sprouts are ready in about 3 days, when their length reaches about 6 mm. Sprouted beans are cooked in the same way as ordinary beans, but the cooking time is shorter than for beans that were just soaked in water.

Most of these statements are not a result of scientific work, but the fact is that in the selection of foodstuffs recommended for nutrition, the advantage is given to plant species that are grown in the region of living. For that reason, the interest in the seeds of beans produced from domestic varieties is justified, while the tradition of consumption shows that, by its specific qualities and nutritional properties, they suit the needs of consumers in the region.

The research presented in this paper was focused on analysing the change in nutritive contents in dry seeds and sprouts grown from three domestic beans varieties: Bosna, Darko and Igman (created in the Federal Institute of Agriculture in Sarajevo) and possible changes that may occur in the germination process.

MATERIAL AND METHODS

The materials used were dry grains of three domestic beans varieties: Bosna, Darko and Igman cultivated in the Butmir locality in the vegetation period of 2011.

According to data from the authors, the variety Bosna belongs to *Phaseolus vulgaris var. nanus*. It is a low growing beans variety. It has a white flower, flat medium sized pods and speckled grains – wine red with dusty pink-beige speckles. The absolute grain weight is about 540g (S. Vukašinović et al. 2008.).

The variety Darko belongs to *Phaseolus vulgaris var. multiflorus*. It is a high growing beans variety and needs support for growing. It has a red, cluster-like flower, flat big pods and black grains with purple speckles. Absolute grain weight is around 1300g. This variety is intended, first of all, for salads and various stews. Cooked beans have a characteristic chestnut flavour, which may be an acceptable characteristic of traditional dishes with beans of the distinctive Bosnian-Herzegovinian quality. (Ćota et al. 2006.).

The Igman variety belongs to *Phaseolus multiflorus var. nanus*. It is a low growing bean variety and it needs no support for growing. It has a white, cluster-like flower, flat large pods and white grains. The absolute weight of the grain is about 890 g (S. Vukašinović et al. 2008).

The research presented in this paper includes laboratory experiments on samples of dry grains and the sprouts grown from them. In dry grains, the grain size and weight were determined, while in germinated grains those were: the development phase, germination time, sprout length, seedling weight and the water absorbing capacity in the swelling process. The analysis of the content of dry matter, water, proteins, hydrocarbons (total sugars, starch) and fats, and their energetic values was also conducted in the samples of varieties tested of both dry and sprouted bean grains.

This experimental method was adjusted to activities that consumers could do on their own while growing sprouts in their own households.

For each variety tested, 100 grains in 4 repetitions were taken and placed in Petri dishes on filter paper, where water was added in different quantities, adjusted to the weight of the grains of the concerned variety (grains immersed in water). Under such humidity conditions, the bean grains were kept for 24 hours, after which, an excess water was removed and over the coming days were kept at the level of substrate and environment humidity at the constant value of 97%. Measurements were made after five (for varieties Bosna and Igman) and seven days (for the variety Darko) upon placing the samples in thermostat at the constant temperature of 25^{o}C.

In all sprouted grains, the grain width and length were measured, as well as the sprout length and the weight. The hypocotyl length was measured from the point of transition of the radicle into hypocotyl (the last root hair) to the top of the hypocotyl (the basal part of the cotyledon). The values of the dimensions measured are expressed in millimetres (mm), and of weight in grams (g).

The laboratory analysis of raw and sprouted grains of domestic bean varieties, also included the determining of the content of hydrocarbons, proteins and fats (energetic contents) and were conducted by standard methods:

- Moisture content - drying at 130^{o}C;
- Total proteins - Kjeldahl;
- Fats, as percentage of dry matter - Soxhlet;
- Total sugars content - Titrimetry.
- Starch - by Ewers.

The data obtained from laboratory research was processed statistically through variance analysis and presented for those parameters where there was a justified need to do so.

RESULTS AND DISCUSSION

Many research activities on the quality properties of bean grains have concerned its properties as a seed for sowing. In that regard, the quality parameters were observed and laboratory analysis conditions, provided in accordance with the methods prescribed for specific plant species. For that reason, the results we have obtained can only be partially compared to the analysis and results from seed production. There are very few results from available scientific work that concern the production of bean sprouts as a foodstuff, with all the indicators of the nutritive quality properties.

It is well known that water, oxygen, temperature and light are basic external seed germination factors. All of these factors interact, and if one of these factors is not optimal for the species concerned, then germination will not take place. Water is necessary for assimilation, absorption, the circulation of nutritive substances, growth and development. Oxygen is needed for the exchange of substances, that is, it is necessary for oxidation; temperature is also of key importance for swelling; light, the absence of which means no germination in some species and in most cases, it is the reason for germination failure.

Earlier research work (Hadžić, A. 2000.) shows that beans belong to plant species where the presence or absence of light is not significant for successful germination, which leads to conclusion that sprouts may be produced successfully in a household, growing them in a suitable place under the conditions of natural change of daylight and night. For this reason, in the process of defining the method of work, light was not taken as a research factor.

The seed swelling process starts with penetration of water into the seed, which is fast at the beginning, but after a few days it slows down and then stops at the moment when its content reaches a certain limit. In the first phase that we call swelling, the seed absorbs water on its own. In the second germination phase,

the transformation of reserve substances in other forms begins, while the third phase begins with the radicle breaking though the seed skin, where growing processes prevail.

In the analysis of the results from testing the morphological properties of dry beans from the bean varieties tested (Table 1), that is, its size and mass of 1000 grains, the pronounced differences in grain size can be noted. The Darko variety has the largest grain, the weight of which is 2.43 times higher than that of the Bosna variety, and 1.60 times higher than that of the Igman variety.

Grain size is a well-known seed quality parameter and there are many papers in that say so in regard, but data on production of sprouts is insufficient.

Table1. Some morphological characteristics of the tested varieties of dry beans

Variety	Length of dry beans in mm	Width of dry beans in mm	Weight of grain in g
Bosna	14.42	6.22^{--}	546
Darko	18.00^{++}	12.90^{++}	1328
Igman	12.90^{--}	8.30^{-}	830
Average	15.11	9.14	899
LDS 5%	1.20	0.85	
LDS 1%	2.05	1.30	

Water quantity in the initial germination phases is an important indicator and a parameter in drafting the instructions for the production of seed sprouts for specific plant varieties. Excessive humidity in certain phases of sprout development or a lack of water in the swelling may affect its quality. Our experiments, started by adding the water in sufficient quantities to immerse the seeds over the first 24 hours, followed by keeping the seeds in an atmosphere with humidity of 97% proved also to be acceptable from the viewpoint of health safety of the sprouts produced. The measurement of the grain size for specific varieties after swelling, and their weight, shows the effects of different water absorption capacity (Table 2.), which differ depending on the variety. The water absorption capacity is the highest in seeds of the Bosna variety (170.4%), followed by the Darko variety (130.3%), and the lowest in the Igman variety (118.1%).

It was proven that at the beginning of the germination of bean seeds in the laboratory, after four days, the initial growth and development was stronger, so germination and sprouting occurred in seeds of a smaller fraction, followed by a medium fraction seed and then a non-calibrated seed, while seven days later, the longest sprout occurred in bean seeds of a larger fraction (J. Haramija, 2007.). The same author also notes that, although the results of the research on the influence of bean seed size on sprout length showed that after four days, sprout (hypocotyl) length is significantly lower in larger fractions when compared to other seed fractions, the significantly lower in sprout (hypocotyl) weight after 4 days of examination was found in small fraction seeds (1.46 g), contrasting to

medium fraction seeds (1.63 g), larger fractions (1.65 g) and non-calibrated seeds (1.65 g). Moreover, stronger initial growth and development, germination and sprouting occur in seeds of a smaller fraction.

Table 2. Some morphological characteristics of seedlings of the tested varieties of beans

Variety	Length of seeds after Swelling, mm	Width of seeds after swelling mm	Length of sprouts, mm	Weight seedlings, g	Water absorption capacity, %
Bosna	21.77^{-}	10.33^{--}	22.15	1.46^{--}	170.4%
Darko	26.90^{++}	17.18^{++}	22.01	3.04^{++}	130.3%
Igman	20.10^{--}	13.62	19.83	1.81-	118.1%
Average	22.92	13.71	21.33	2.10	139.6
LDS 5%	0.80	1.85	2.05	0.48	
LDS 1%	1.15	2.02	3.40	0.60	

The research presented in this paper shows that the varieties of smaller grain weight (Bosna and Igman) reached the sprout length that is considered the most suitable for diet, when it comes to nutritive properties (sprouts twice the length of the seed), after four days, while for the largest grain of the Darko variety this phase was reached after six days (Image 1.).

a b c

Image 1. Sprout development phases of the bean varieties analysed: a) Bosna, b) Darko, c) Igman.

The assertions of Kovalchuk (1977), who states that grains of smaller weight have a thinner skin, which is more permeable for water, so they germinate more quickly, and may partly be (in the absence of data on detailed scientific research work) an indicator of the correlation with our results. But the fact that the water absorption capacity is not proportionally higher when compared to the size of the grains of the analysed bean varieties (grains of the Bosna variety had the highest water absorption capacity of 270.4% compared to the dry grain weight, which is the smallest in this variety), leads to an assertion that the water absorption capacity is not related to the size of the seed, which, in this case, is the trait of the variety concerned.

Kolak (1994) states that larger soya beans usually give weaker seedlings when compared to small and medium sized seeds. Guberac (1996) ascertained that seed size showed a highly justified statistical influence on hypocotyl length. The longest hypocotyl was achieved in small soy grains, followed by standard, then by medium sized grains, while the shortest hypocotyl occurred in the large soya seeds.

In the bean grains used in our research, there are no differences in sprout lengths among the varieties, but the seedling weight is the highest in the largest seeds of the Darko variety (3.04 g) (Table 2.).

Generally, it can be said that commercial size sprouts can be grown in the period of four days for seeds of the Bosna and Igman varieties and six days for the Darko variety. The ratio of weight of raw seeds and seedling varies depends on the variety concerned and the results show that from 1g of raw seeds, we can produce 1.46g of raw sprouts from the Bosna variety (weight ratio between dry and sprouted grain 1:2.7), 3.04 g in the Darko variety (1:2.3) and 1.81g in the Igman variety (1:2.2).

Previous research work (Hadžić et al. 2012.) points to the differences that exist in nutritive values of dry seeds of certain domestic bean varieties (Bosna, Darko and Igman), resulting in different energetic values: 526.92 kJ for the Bosna variety, 532.64 for the Darko variety and 537.28 kJ for the Igman variety.

If we analyse the data obtained for each variety separately, the differences in values of the specific parameters analysed are noted (Table 3.). In germinated seeds of the Bosna variety, there is an increase in the protein content compared to the dry seed of 7.58%, in the Darko variety it is 6.35% and in Igman 6.73%.

The highest recorded reduction of the total sugar content in germinated seeds compared to the dry bean was in the Igman variety (by 0.97%), followed by Darko variety (by 0.5%), and the lowest in the Bosna variety (by 0.2%).

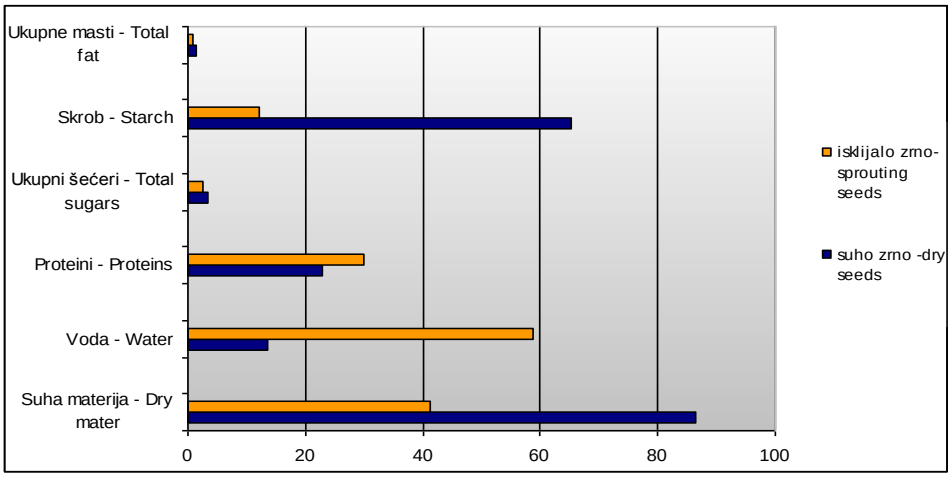
The largest differences in the reduction of the content of certain nutrients were recorded in starch, where starch content fell from 66.04% in raw dry seeds of the Darko variety to 10.12% in germinated seeds (less by 53.92%), followed by the Igman variety from 64.07% to 12.92% (by 52.31%), and then in the Bosna variety from 65.78% to 13.41% (by 51.15%).

Table 1.: Results of the chemical analyses of dry and germinated seeds in the studied domestic bean varieties

Contents	Variety Bosna		Variety Darko		Variety Igman	
	Dry seed	Germinated seed	Dry seed	Germinated seed	Dry seed	Germinated seed
Dry matter %	86.4	39.15	86.47	46.24	86.77	37.98
Water %	13.6	60.85	13.53	53.76	13.23	62.02
% in relation to dry matter						
Proteins	25.28	32.86	21.18	27.53	22.45	29.18
Total sugar	2.40	2.38	3.35	2.85	3.36	2.39
Starch	64.07	12.92	66.04	10.12	65.78	13.41
Total fat	0.84	0.62	1.34	0.90	1.73	0.62

Seed germination had the lowest impact on the change in fat contents compared to the content in dry grains of the bean varieties concerned. The reduction in fat content ranged from 0.22% in the Bosna variety, then 0.44% in the Darko variety to the highest reduction of 1.11% in the Igman variety.

Water content in germinated seeds in all three varieties rose by 3.4 times on average.



Graph 1.: The average values of the nutrients in dry grain and sprouting seeds of local beans' varieties

The overview of the nutritive values of sprouts compared to raw seeds for all of the studied varieties gives, on average, a proportion of changes similar to those in the variety-specific data, so in germinated seeds, the dry matter content is lower (by 52.48 %), as well as total sugar (by 16.45 %), starch (by 81.4%) and

fats (by 45.39%). Only the protein content rose in germinated seeds, by 29.0% on average (Graph 1.).

There are research activities and results that, by many indicators of the nutritive values of the bean sprouts obtained, correspond with the results of our work when it comes to the general assessments of the increase or reduction in their content. However, there are differences when it comes to the percentages of increases or reductions, with regard to properties of grains in specific domestic varieties in the BiH that were analysed. Todorović et al. (2008) state that in the germination process, the protein content multiplies along with the reduction of the share in calories and hydrocarbons. Compared to dry seeds, vetches and cereals, the share of water in sprouts is ten times higher.

The analysis of the chemical composition of the five domestic bean varieties *Phaseolus vulgaris*, (Tepić et al., 2007) shows distinct differences in their nutritive values in relation to the properties of the variety concerned. The dry matter content ranges from 90.06 to 93.30%, total sugar from 5.8 to 7.57%, starch from 51.00 to 53.71%. There is no data or comparison of the dry seeds with the germinated seeds of the studied bean varieties.

According to the USDA data (2007), with regard to their nutritive value, 100g of bean grains contain: proteins 23.58 g in total; hydrocarbons 60.01g in total and fats 0.83g in total. Some data shows that change in nutritive values occurring in the transformation of the seed into a sprout also implies the reduction in the content of energy and hydrocarbons by 15 %, while availability of proteins rises up to 30 %.

By following the changes in the values of nutrients in germinated seeds of the analysed domestic bean varieties and the fact that the contents of those nutrients directly influence the energetic values are reduced, so we can say that our research confirms the fact that sprouts from an edible plant species may be more acceptable foodstuffs for those categories of consumers who choose foodstuffs of higher digestibility rate and lower energetic value.

CONCLUSIONS

The analysis of nutritive values of germinated seeds in the domestic bean varieties of Bosna, Darko and Igman, resulted in the new notions:

- The Darko variety has the largest seed weight, of which is 2.43 times higher than the grain of the Bosna variety, and 1.60 times higher than that of the Igman variety.
- Water absorption capacity is the highest in seeds of the Bosna variety (170.4%), followed by the Darko variety (134.03%), and the lowest in the Igman variety (118.1%).
- Varieties of the smaller grain weight (Bosna and Igman) reached a sprout length that is considered the most suitable for nutrition (sprouts 2x seed length) in four days, while in the largest seed of the Darko variety that phase was reached after six days.

- There are no differences between the lengths of sprouts in specific varieties, but the seedling weight was the highest in the largest seeds of the Darko variety (3.04 g)
- From 1g of grains we can produce 2.7 g of raw sprouts in the Bosna variety, 2.3 g in the Darko variety and 2.2 g in the Igman variety
- In germinated seeds of the Bosna variety, the increase of proteins compared to the dry seeds is 7.58%, in varieties Darko 6.35% and Igman 6.73%.
- Reduction of the contents of total sugars in germinated seeds compared to the dry bean seeds is the highest in the Igman variety (by 0.97%), followed by the Darko variety (by 0.5%), and the lowest in the Bosna variety (by 0.02%).
- The reduction of starch in germinated seeds was the highest in the Darko variety - by 53.92%, followed by the Igman variety by 52.31%, and in the Bosna variety the reduction is 51.15%.
- The reduction in fat content in germinated seeds ranges from 0.22% in the Bosna variety, and 0.44% in the Darko variety, while the highest reduction of 1.11% was recorded in the Igman variety.

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ISPITIVANJE HRANJIVIH VRIJEDNOSTI ISKLIJALOG SJEMENA DOMAĆIH SORTI GRAHA U BOSNI I HERCEGOVINI

SAŽETAK

Klijanje sjemena uzgajanih biljnih vrsta je najčešće proučavano sa aspekta poljoprivrednih kvaliteta, a zadnjih nekoliko godina i kao mogući izvori nutritivnih vrijednosti klica u ishrani. Klijanci sjemena jestivih biljnih vrsta se preporučuju kao dijetetske namirnice zbog nutritivnih sadržaja u prihvatljivijim formama za organizam nego su to u sirovom zrnu.

Ispitivanja u okviru ovog rada obuhvataju tri domaće sorte graha: Bosna, Darko i Igman, kod kojih su određivane karakteristike suhog zrna (velićina zrna, masa zrna) i klijanaca (faze razvoja, vrijeme klijanja, dužina klica, masa klijanaca), kapacitet upijanja vode u fazi bubrenja, te sadržaj suhe materije, vode, proteina, ugljenih hidrata (ukupnih šećera, skroba) i masti, te njihove energetske vrijednosti.

Rezultati istraživanja ukazuju da je za period od četiri dana za sjeme sorata Bosna i Igman i šest dana za sortu Darko moguće proizvesti klice konzumne veličine. Odnos mase sirovog zrna i klijanaca je različit kod pojedinih sorata, tako da iz 1g sirovog zrna možemo proizvesti 2,7 g sirovih klica kod sorte Bosna, 2,3 g kod sorte Darko i 2,2 g kod sorte Igman.

Slika nutritivnih vrijednosti klica u poređenju sa sirovim sjemenom za sve tri ispitivane sorte u prosjeku se mijenja, tako da su u isklijalim sjemenkama manji sadržaji suhe materije (za 52,48 %), ukupnih šećera (za 16,45 %), škroba (za 81,4%) i masti (za 45,39%). Jedino se, kod isklijalih sjemenki povećava sadržaj proteina za 29,0%.

Ključne riječi: grah, klica, masa, nutritivne, energetske vrijednosti.