

IMPACT OF SOLAR DRYING ON NUTRITIONAL PROPERTIES OF CERTAIN VARIETIES OF GREEN BEANS

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Abstract

The green beans are significant agricultural crop with good nutritional properties. Usually the young legumes are used for human consumption. In this research three varieties were used such as, yellow, green and colorful butter green beans, from the vicinity of Skopje. The technology of drying was performed in the solar dryer, after application of blanching as a pretreatment. To estimate the impact of the drying process on the nutritional properties, examinations were made for the following parameters: carbohydrates, proteins, oils, water, total dry matter and the energy value. For the fresh green beans was estimated the highest value of total dry matters (11.81 %), for the variety *green molivka*, as well as for the energy value (50.75 kcal). The dried variety of *colorful butter* green beans was distinguished by the highest value (90.56 %) of total dry matters and the highest energy value (374,85) kcal was estimated in the dried variety of *golden molivka*.

Keywords: green beans, fresh, drying, nutritional properties

1. Introduction

Among the vegetables, the *Fabaceae* constitute a broad and very large botanical family, consisting of more than 450 genera and over 12,000 species. Many species are important as food sources for humans and animals. Beans, a major constituent of this family, are utilized both, for fresh green pods as vegetable and dry seeds as pulse (Yamaguchi *et al.*, 1997). The common bean is an annual plant, grown worldwide specifically for their edible beans. Green beans are a summer vegetable crop with fairly short growing season. There are two main classifications of beans: the edible pod beans and shell beans, and the colors and shapes of each vary tremendously.

The green beans are edible pod beans that can be grown as bush beans or pole (running) beans. They are often referred to as string beans because a fibrous string originally ran along the seam of the bean pod. The string is noticeable when snapping off the ends of the pod. This snapping noise is the reason for its other common nickname, *snap beans* (<http://plantanswers.tamu.edu>). According to the shape, size and the color there are different bean names. Based on the size, the classifications are: small (<25 g /100 seeds), medium (25 g to 40g) and large (> 40g/100 seeds). Regarding the form, the grain can be round, oval, elliptical, rhomboid, kidney-shaped, prismatic and cylindrical (Romero-Arenas *et al.*, 2013). Pods are almost always considerably longer than wide; lengths range from 8 to 20 cm or more, with widths of less than 1 to several cm. Depending on cultivar, pod ends may have a pointed or blunt tip; cross-sectional shapes vary from round to elongated oval, and some are heart shaped. The pod color of green beans can be green, golden, purple/red, or even streaked, but the beans inside the pod are always green. Pods of most present-day cultivars are relatively straight, although some are normally curved. Most cultivars have light to dark bluish green pods; others are yellow (wax), purple, or multicolored.

The seed number is another cultivar characteristic; most snap bean cultivars contain three to five seeds; dry or common bean types tend to have several more. Mature seed sizes exhibit enormous variation in size and weight, ranging between 5 and 20 mm in length and the individual seed weight of some cultivars vary from 0.15g to more than 0.80 g. The seed shapes are round, orbicular, ovoid, oblong, and kidney. The seed coat colors are cultivar-specific, can occur in numerous colors and combinations, and are of some importance.

The harvest decisions for snap beans are based on the stage of the pod development. For high yields, the snap bean pods should achieve maximum length before significant seed enlargement takes place and while the pod is still succulent. The ideal situation is to have all pods at the same stage of development. For the green beans, it is essential from a nutritional and marketing point of view that the growing pods are harvested at a right stage to optimize the gains with respect to their yield and quality (Saxena et al., 2010).

After harvesting, the green beans need to be cooled as quickly as possible to minimize quality deterioration resulting from the biochemical changes or the respiration (Brosnan and Sun 2001). The snap bean pods have a high respiration rate and should be rapidly cooled to about 5 °C and maintained at 95 % RH. Temperatures less than 3 °C for more than several days need to be avoided because they cause chilling injury. Pod shelf life of acceptable quality for 2-3 weeks is achievable with storing the green beans at 5-10 °C and 95 % RH (Rubatzky et al., 1997).

The shelf life of the green is very short and it can be significantly expanded by different processing techniques, as drying, canning and freezing. Each of these techniques can be used commercially and by domestic approaches. If processed properly and the storage packing is properly sealed, all approaches could produce safe and nutritious processed food with extended shelf life (Sinha, 2011).

The nutritional and biological value of the green beans are determined according to the content of proteins, carbohydrates, oils, cellulose, vitamins and other components. According to the data from USDA-NDL (2009), the following proximate nutritional composition in 100 g of fresh green beans was assessed: water 90.32 g, carbohydrate, by difference 6.97 g fiber, total dietary 2.7 g, protein 1.83 g, total lipid (fat) 0.22 g, ash 0.66 g, minerals as: calcium 37 mg, magnesium 25 mg, phosphorus 38 mg, potassium 211 mg, sodium 6 mg, as well vitamins: vitamin C, total ascorbic acid 12.2 mg, folate, total 33 µg, carotene, beta 379 µg, vitamin A, 690 IU, lutein + zeaxanthin 640 µg, vitamin K (phylloquinone) 14.4 µg and the total energy value of 31 kcal. The vitamins A and C contained in the green beans are excellent antioxidants that reduce the amounts of free radicals in the body and prevent the building up of plaque in the arteries and veins. The green pods are rich source of proteins, minerals and vitamins (Punia et al., 2008). The fresh raw green beans are a major vegetable type that consumers purchase for consumption, while processed vegetables in dried, frozen and canned forms are also available.

The green beans can be processed at the domestic level before consumption. The domestic processing brings about a significant change in the sensorial properties and nutritional qualities of the vegetables (Kala & Prakash, 2006). The processing consists of a succession of operations combining purely (bio) chemical reactions and physical changes (diffusion or mass transfer), causing quantitative and qualitative changes in the food constituents (Pouillot et al., 2003). It could be highly relevant to the predictions of chemical transformations, with particular losses in micronutrients during the processing of the foods. For instance, the initial concentrations of micronutrients are variable, or chemical parameters should be given with some uncertainty due to the approximation in their estimation (Rigaux et al., 2016). Depending on the conditions applied, the nutritional quality decreases, e.g. amount of nutrients and phytochemicals, although the bioavailability of certain compounds such as carotenes increases (Dekker et al., 2000). The changes in the sensorial properties such as texture and color are assumed to be controlled during the processing to meet appropriate sensory preferences, to be acceptable for consumption.

Drying can be described as an industrial preservation method in which water content and activity of fruits and vegetables are decreased by heated air to minimize biochemical, chemical and microbiological deterioration. The major objective in drying of the agricultural products is the reduction of the moisture content to a level that allows safe storage over an extended period of time. Also, it causes a substantial reduction in weight and volume, minimizing packaging, storage and transportation costs (Doymaz, 2004).

The most common drying method for vegetables in the world is open air-sun drying. This drying technique has some disadvantages: Its' time-consuming, causes exposure to environmental contamination, and requires significant manual labor. Furthermore, the direct exposure to a solar radiation results in undesired color changes. In addition, the quality of the dried products may be significantly lowered. Therefore, using solar and hot air dryers, which are far more rapid, and provide uniformity and improved hygiene, are inevitable for industrial food drying processes (Doymaz & Pala, 2002; Karathanos & Belessiotis, 1997).

2. Materials and methods

Although the green beans, as a leguminous vegetable have good nutritional properties, there a lack of scientific data for nutritional composition of different varieties of green beans, especially in Macedonia. Therefore, the main goal of this paper is to estimate some nutrients in the fresh pods of the most common used green beans, as well as their changes due to the application of the drying process.

In this research were used pods of three varieties of green beans (*golden molivka*, *green molivka* and *colorful butter* green beans), produced by individual farmers at the villages in the vicinity of Skopje. The fresh pods of all of the examined varieties of the green beans were measured in their length and width, as well their sensorial properties (appearance, color, taste and smell) and nutritional composition.

The drying process was performed at home conditions. For that purpose, young healthy and fresh pods of green beans were used, without mechanical damage, where the ends were cut off. Then the pods were washed with clean water and each pod was cut into 2 to 3 pieces and placed in a pot of boiling water for blanching, at a temperature of 85 °C for 5 minutes. Blanching helps the beans to dehydrate quicker. It releases some of the juices and stops enzyme actions. Then, the pods were plunged into cold water in order to stop the cooking process, and were drained afterwards. The sensory evaluation (appearance, color, taste and smell) was performed on the blanched pieces of green beans.

The process of drying is performed to evaporate the free water in order for the microorganisms to become disabled, and to decrease the weight and the volume of the pods. At the same time, the amount of dry matter increases, which increases the all nutrient components. The home drying oven was used to dry the already prepared pieces of pods green beans, for all examined varieties. The drying was performed at a temperature of 60 – 70 °C, for 5 hours and then the temperature was reduced to 40 – 50 °C. During the drying process, the pieces of the green beans were frequently stirred and turned over. The dried green bean pieces were packaged and stored in airtight containers.

The dehydrated pieces of green beans were tasted to estimate their sensorial properties (appearance, color, taste and smell) and evaluate the same nutritional components as in fresh ones: water and total dry matters, by using drying ovens, at a temperature of 105 °C, to a constant mass; proteins by Kjeldahl method; lipids by the Soxhlet method (Vračar, 2001); total carbohydrates were calculated, by the determined values for proteins, lipids and the content of water; the total energy value represents the sum of the energy value of proteins, fats and total carbohydrates, expressed in calories (kcal) or kilojoules (kJ). The applied methods were standard laboratory methods, with proved statistical precision, accuracy and repeatability of the results.

3. Results and Discussion

By measuring the length and the width of the pods, it was estimated that the variety *golden molivka* had a width of 0.8 to 1 cm and a length of 10-13 cm; the variety *green molivka* had a width of about 1 cm, with a different length of 14 - 18 cm and the *colorful butter* green bean pods were characterized by a width of 1 to 1.5 cm, with a length of 12 to 15 cm. Comparing to literature data from other research, (Ljubosavljević, 1989), these three varieties are characterized with: 12 to 15 cm in length and about 1 cm in width for *golden molivka*; 1 cm width and length of 14 - 18 cm for *green molivka*; length of about 10 cm for *colorful butter* green beans.

According to the estimation of the sensory properties of the fresh varieties of the green beans, the pods of the variety *golden molivka*, in fresh condition were characterized by a golden-yellow color, poorly expressed aroma and typical taste of green beans, with straight, round shape, with poorly expressed aroma, fragile and juicy. The blanched pieces of the green beans of this variety got softer, their color did not change, but their aroma and taste became weaker. By drying, the pods became solid, without special taste and aroma. The yellow color turned to yellow-brown. The fresh pods of the variety *green molivka* had green color, with a distinctive flavor and taste for green beans that are poorly expressed, round and straight in shape, fragile and juicy. After blanching, the pods got softer, without changing of color, and the taste and the aroma were of a lower intensity. The dried pieces were characterized by yellowish green color, with almost no flavor and taste. The fresh variety of the *colorful butter* green beans pods were flattened in shape, straight, fragile and juicy, with a flavorless taste and a weak characteristic aroma. The pods were yellow, with anthocyanin spots. After blanching for 10 minutes, the anthocyanin spots disappeared, the color became yellowish gray, the pods became soft, and the flavor and the taste were even weaker. It is interesting to note that if the process of blanching lasts 3 to 4 minutes, the anthocyanin spots remain unchanged. The dried pieces became solid, with retained color and shape, more so than the other two varieties.

To estimate the total nutritional value of the examined samples of fresh, blanched and dried green beans the following parameters were analyzed: water, total dry matter, total carbohydrates, proteins and oils. For obtaining the energy values, the calculations were made according to the content of essential nutrients and the results were expressed in kcal or kJ.

In the Graph 1 below are presented the results obtained from all examined samples of varieties and conditions of the green bean pods. The fresh pods of the green beans were characterized by the highest values for: the total dry matters (11.81 %) and total carbohydrates (8.10 %) in the variety *green molivka*; the protein (3.78 %) and oils content (1.24 %) in pods of the variety *golden molivka*. The lowest value of total dry matter (9.75 %) had been noticed in the variety *colorful butter* green beans, which means that the water content (90.25 %) had the highest value.

The results from examination of blanched pods of green beans shows that the variety *colorful butter* had the lowest value of total dry matter (6.90 %) or the highest value of water content (93.10 %). On the other hand, the variety *green molivka* had the highest values for the total dry matters (10.80 %) and total carbohydrates (7.84 %), while the highest values for proteins (3.12 %) and oils (0.78 %) were measured in the variety *golden molivka*.

From the Graph 1 it can be noticed the highest values for the dried pieces of green beans as following: the total dry matters (90.56 %) and total carbohydrates (69.17 %) in the variety *colorful butter* green beans; the proteins (24.26 %) and oils (1.08 %) in the variety *golden molivka*. Despite this, the variety *green molivka* had the lowest value (89.75 %) of total dry matter, what results the highest content of water (10.25 %).

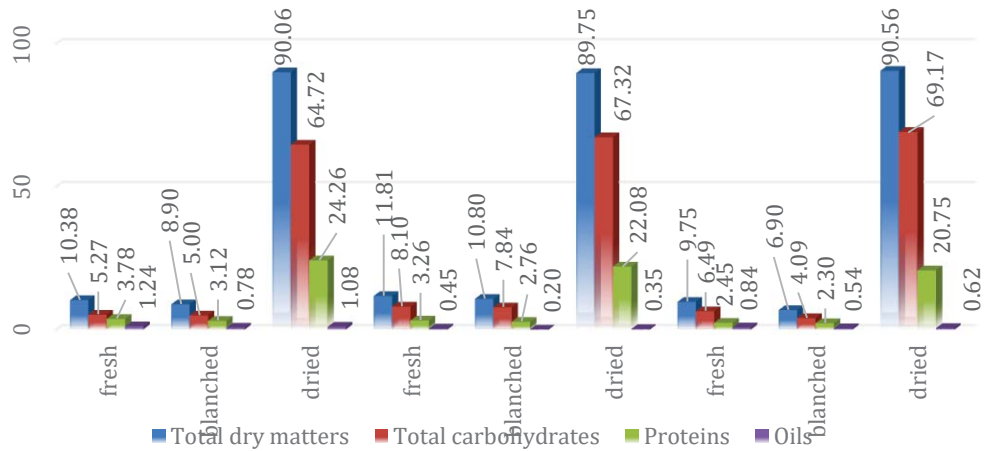


Figure 1. Nutritional value ing/100 g of the examined varieties of green beans

In terms of the nutritional properties of the examined varieties presented in Graph 1, it is noticeable that the pods of *golden molivka* variety had the highest content of proteins (24.26 %) in dried pieces and oils (1.24 %) in the fresh pods of green beans. The variety *colorful butter* green beans had the highest values for water content (93.10 %) in blanched pods and the highest values for total dry matter (90.56 %) and total carbohydrates (69.17 %) in dried pieces of green beans.

Based on the obtained results for nutrients composition, the energy values were empirically calculated (Graph 2.) for all of the varieties of green beans that were analyzed in this research. The highest energy value had the fresh pods of the variety *green molivka* (50.75 kcal or 212.46 kJ) and also the blanched ones with 45.31 kcal or 189.69 kJ; the dried pieces of the variety *golden molivka* had the highest energy value 374.85 kcal or 1569.16 kJ and the colorful butter green bean had almost similar energy value (374.48 kcal or 1567.64 kJ).

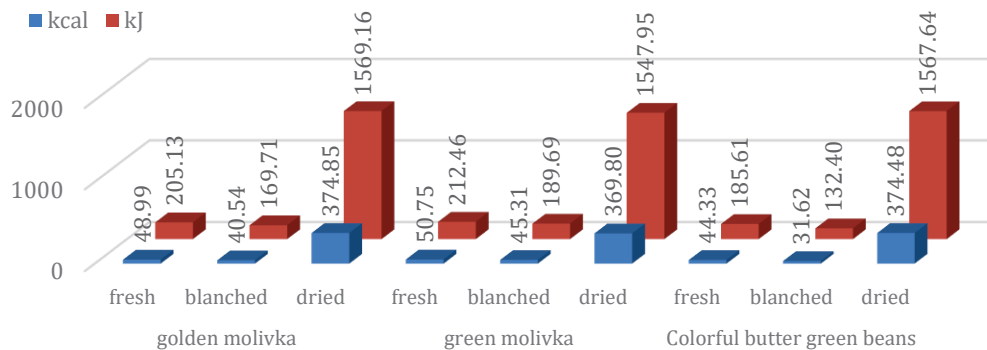


Figure 2. Energy values in g/100 g of the examined varieties of green beans

The highest difference in the content of the total dry matter between the fresh and the blanched pods (2.85 %) and between the fresh and the dried pods of 80.10 % had the variety *colorful butter* green beans. Among the dried varieties, the difference of the total dry matter was the lowest (0.31 %) between the *golden molivka* and *green molivka*, and the highest (0.81 %) between *green molivka* and *colorful butter* green beans.

Taking into the account the fact that in the content of total dry matter are included all nutrients that participate in the energy value of the food, similar differences were estimated between the examined varieties. The variety *colorful butter* green beans had the highest difference of the energy values (12.71 kcal) between the fresh and the blanched pods, as well as between the fresh and the dried ones (330.15 kcal). In terms of the varieties of dried pods, the lowest difference of the energy values (0.37 kcal) was

estimated between the *golden molivka* and the *colorful butter* green beans. Unlike this, the highest difference (5.05 kcal) was estimated between the *golden molivka* and *green molivka*.

4. Conclusions

According to the results in this research, it can be concluded that all of the examined varieties of fresh and dried green beans had a nutritional composition with satisfactory content of the essential nutrients, as well as the energy values.

It was estimated that the dried green beans had low percent of water content, about 10 %, which means that the rest of the content is the total dry matter. In the content of the total dry matter are included all of the nutrients, from which the most are total carbohydrates, then proteins, while the content of oils is significantly low. Comparing the content of nutrients and energy values of the fresh and the blanched pods of green beans, all of the examined dried varieties had the highest obtained values. The highest values (90.56 %) of total dry matters had the pods of dried variety *colorful butter* green beans. The dried pods of the varieties *golden molivka* and *colorful butter* green beans had almost similar estimated high energy values 374.85 kcal and 374.48 kcal respectively.

The advantage of the dried green beans is that they can be stored for a longer period of time, even up to 2 years. Despite its advantages, dried green beans are poorly used in our country despite the fact that we have excellent growing conditions.

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