# PRODUCTION OF THE ENRICHED MUESLI BARS UNDER MINIMAL PROCESSING TREATMENT

**ORIGINAL SCIENTIFIC PAPER**

*Martina Andrejaš, Dijana Miličević✉, Gordan Avdić, Hurija Alibašić*

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Faculty of Technology, University of Tuzla, Urfeta Vejzagića 8, 75000 Tuzla, Bosnia and Herzegovina

✉ dijana.milicevic@untz.ba

**ABSTRACT:**
**Muesli bars is a generic term that refers to baked or cold-formed cereal-based snack bars, and may contain other ingredients such as fruit, nuts, seeds, chocolate, yoghurt, and a variety of other fillings and/or toppings. By changing the ingredients nutritional value of muesli bar can be modified. In this research, protein-rich and energy-high muesli bars have been produced, because they contain a higher amount of fat, proteins and sugar. However, fats and sugars were not added but come from specific ingredients (hazelnuts, walnuts, chia seeds, sesame, sunflower and pumpkin seeds, oat flakes, etc.). Four muesli bar formulations were developed, two with hazelnuts and two with walnuts, added in the amount of 25% and 50%, respectively. The other ingredients were added in the same amount. The product was dried at 80°C for several hours. The composition, polyphenolic compounds and antioxidant capacity were determined in the products before and after drying. Also, muesli bars were sensory evaluated.**

**KEYWORDS: muesli bar, hazelnut, walnut, oat flakes, drying.**

## INTRODUCTION

Snack consumption has increased significantly in recent years [1]. Chocolate bars, crisps, cakes and pastries are unhealthy snacks that have a high content of saturated fat, salt and refined sugar which can cause health problems [2]. Due to that, many people intend to change their unhealthy behaviors, such as their bad habit of consuming high-caloric foods [3]. Nowadays, the consumer demand of healthy snacks and minimally processed foods are increasingly popular because consumers want fresh like foods with their natural nutritive values and sensory attributes, such as flavor, odor, texture and taste [4]. This growing consumer's demand of minimally processed foods with no or lesser synthetic additives poses challenges to food technologists [5].

Minimally processed products have been defined as "any fruit or vegetable, or any combination thereof, which has been physically altered from its original form, but has remained in its fresh condition" [6]. The aims of minimal processing are: to make the food safe chemically and microbiologically; to retain the desired flavor, color and texture of the food products and to provide convenience to the consumers [7]. Minimal processing of foods with thermal methods is extensively used for the preservation and preparation of foods. HTST (high temperature short time) and LTLT (low temperature long time) concept are used. High temperatures will give the rapid inactivation of microorganisms and enzymes required in pasteurization or sterilization, and short times will give fewer undesired quality changes. If effective control is not possible, thermal processing is better done using the LTLT concept, using low temperatures over long times. This process improves shelf-life and sensory and nutritional quality by controlling causes of negative changes in quality such as exposure to oxygen and extreme temperatures [8].

In this research, muesli bars were produced under minimal processing treatment. The product was dried in a food dehydrator at 80°C for several hours. A mixture of different seeds with the addition of hazelnuts and walnuts has been used. Four muesli bar formulations were developed. Two formulations were with hazelnuts and two with walnuts, added in the amount of 25% and 50%, respectively. The other ingredients (sesame seeds, flaxseed, chia, sunflower seeds, pumpkin and oat flakes) were added in the same amount. Honey has been used as a sweetener.
Hazelnuts are good source of fats. The lipid fraction of hazelnuts is composed of non-polar and polar constituents. Major nonpolar lipids are the triacylglycerols. It is good source of monounsaturated fatty acid and polyunsaturated fatty acid. It contains predominantly palmitic acid, stearic acid, linoleic acid and linolenic acid. The omega-3 fatty acids are not synthesized by the human body. α-linolenic acid is precursor for omega-3 fatty acids [9].

Walnut is highly rich in terms of monounsaturated fatty acids. It is a perfect source of Omega 3 and arachidonic acid [10].Walnut contains much more antioxidants than the other hard shell nuts. Walnuts reduce: cholesterol, oxidative stresses caused by free radicals and the inflammations that damage the health [11].

Sesame seed contains 57–63% oil, 23–25% protein, 13.5% carbohydrate and 5% ash [12], [13]. Sesame is a rich source of iron, copper, manganese, magnesium and calcium [14]. The presence of sesamin (0.4-1.1) and sesamolin (0.3-0.6)% lignans contributes to oxidative stability and antioxidative activity. Sesamol is found in traces [15], [16].

Chemical composition of flaxseed shows that it contains 41% fat, 20% protein and 28% total dietary fibre. Flaxseed represents a good source of alpha-linoleic acid and phenolic compounds [17].

Chia seeds contain approximately 30–34 g dietary fiber. The insoluble fraction accounts for approximately 85–93%, while soluble dietary fiber is approximately 7–15% [18]. Chia seeds supply many minerals, such as: phosphorus (860–919 mg/100 g), calcium (456–631 mg/100 g), potassium (407–726 mg/100g) and magnesium (335–449 mg/100 g) [19].

100 g of sunflower seed contain 20.78 g protein, 51.46 g total lipid, 3.02 g ash, 20 g carbohydrate and 8.6 g fiber, with total energy of 2445 kJ. Sunflower seed is an excellent source of betaine and choline [20].

The pumpkin seed represents a good source of phosphorus, potassium and magnesium. It contains high amounts of other trace minerals, such as: calcium, sodium, manganese, iron, zinc, and copper. Elements like calcium, sodium, manganese, iron, zinc and copper make pumpkin seed valuable for food supplements [21].

Oat is a cereal that offers extra-functional properties as probiotics carriers over other cereals. Oats are rich source of β-glucan, antioxidant phenolic compounds, dietary lipids and soluble fibers [22].Compared with other cereals (wheat, rice, barley, buckwheat, and rice), oats contain higher content of protein. Oat lipids are rich in polyunsaturated fatty acids, Vitamin E, and plan sterols [23].

Honey can be used as a substitute for sugars, because it has a high content of fructose and a higher sweetness than refined sugars. Most sugars in honey are reducing sugars which are easily browned during baking and give a naturally darker color to the product. The flavor given by the honey to the product has proved to be desirable by consumers [24].

## MATERIAL AND METHODS

Materials used for muesli bars preparation are: sesame seeds, flaxseed, chia, sunflower seeds, pumpkin seeds, oat flakes, hazelnuts, walnuts and honey.

### PREPARATION OF MUESLI BARS

Muesli bars were made using a formulation described in Table 1. All ingredients were mixed and shaped in a shaper machine (Tupperware, USA). Hazelnuts, walnuts, pumpkin seeds and oat flakes were grinded in a grinder (Gorenje, Slovenia) before mixing. Other ingredients were added in a native form. The product was dried in a food dehydrator (Gorenje, Slovenia) at 80°C for six hours. During the preparation of this paper, the results of sensory analysis have shown that crispier products were more desirable, so the products were dried up to a moisture content of about 3%. Four muesli bar formulations were developed, two with hazelnuts and two with walnuts, added in the amount of 25% and 50%, respectively.

**Table 1.** Formulation for preparation of muesli bars

| Materials | 25% of hazelnut/walnut (g) | 50% of hazelnut/walnut (g) |
|---|---|---|
| Hazelnuts/walnuts | 90 | 260 |
| Flaxseed | 40 | 40 |
| Sunflower seeds | 20 | 20 |
| Pumpkin seeds | 20 | 20 |
| Sesame | 30 | 30 |
| Chia | 30 | 30 |
| Oat flakes | 60 | 60 |
| Honey | 60 | 60 |

### DETERMINATION OF THE DRY MATTER CONTENT IN MUESLI BAR

Drying on 105°C in dryer until the constant mass in the muesli bar sample was used [25].

### DETERMINATION OF THE TOTAL ASH IN MUESLI BAR

Burning on 600°C in laboratory furnace (Instrumentaria, Zagreb) was used. The total ash includes an inorganic leftover that remains after the burning and represents the total mineral content of the sample. During the burning, all the cations, beside ammonia cations, turn into carbonates or into others anhydrous inorganic salts. The total ash content was determined by standard gravimetric method [25].

### DETERMINATION OF THE RAW FIBER CONTENT IN MUESLI BAR

The content of the raw fiber was determined by method upon Kurschner-Hanack. This method is based on insolubility of cellulose in water and its resistance to action of dilute acids and bases. The sample was degraded with a mixture of nitric acid and acetic acid and boiled in apparatus equipped with a Liebig's condenser. The solution was then filtered through a Büchner funnel. Then the filter paper containing an insoluble residue was dried in oven and measured [26].

### DETERMINATION OF THE TOTAL AND REDUCED SUGARS IN MUESLI BAR

Reduction of Fehling's solution by a solution of reduced sugars in the muesli bar, using methylene blue as an indicator were used. The content of reducing sugars is determined by volumetric method upon Luff-Schoorl [25].

### DETERMINATION OF THE SUCROSE CONTENT IN MUESLI BAR

The sucrose content is obtained from the difference between total and reduced sugars [25].

### DETERMINATION OF THE FAT CONTENT IN MUESLI BAR

Soxhlet extraction method on the Soxhlet extractor (Velp Scientifica, Italy) was used. Petroleum-ether was used as organic solvent. The fat was collected by evaporating the solvent.

### DETERMINATION OF THE PROTEIN CONTENT IN MUESLI BAR

Kjeldahl method on the Kjeltec TM 2300 device (Foss Tecator, Sweden) was used. Determination of the concentration of total nitrogen was conducted in three phases: wet burning of the sample, distillation and titration. In a cuvette the muesli bar sample was weighed and two catalyst tablets were placed and the sample was burned on the unit for burning. After the total burning, cuvette was transferred to the unit for a distillation. The strong base was added which caused a release of $NH_3$. $NH_3$ was transferred through the cooling system and treated with 1% boric acid which caused an increase of pH value in a solution. This solution was titrated with 0.1 N HCl. Bromine cresol and methil red were used as indicators. The concentration of ammonium ion was determined based on a volume of HCl that was needed for a titration.

### DETERMINATION OF THE TOTAL POLYPHENOLS IN DOUGH AND MUESLI BAR

Folin-Ciocolteu method was used for total phenols determination using spectrophotometer (ThermoFisher Scientific, USA) at wavelength of 756 nm. Gallic acid was used to prepare the standard curve. 0.1 mL of prepared methanol extract was pipetted to the test tubes after which 1.9 mL of a distilled water, 10 mL of Follin-Ciocolteu reagent and 8 mL of sodium carbonate solution were added. Absorbance was measured after 2 hours. The blank was prepared with distilled water instead of the sample.

### DETERMINATION OF THE ANTIOXIDANT CAPACITY IN DOUGH AND MUESLI BAR

FRAP method was used for antioxidant capacity determination using spectrophotometer (ThermoFisher Scientific, USA) at wavelength of 593 nm. $FeSO_4$ X $7H_2O$ was used to prepare the standard curve. 0.1 ml of prepared methanol extract was pipetted to the test tubes after which 3 mL of FRAP reagent was added. Absorbance was measured after 30 minutes. The blank was prepared with distilled water instead of the sample.

### SENSORY ANALYSIS

For sensory analysis DLG method was used [27], [28]. Graded properties were: shape, color, surface; hardness, structure; chewiness; odour and taste.

## RESULTS AND DISCUSSION

As shown in Table 2, dry matter content was similar in all samples, and it was from 96.784% to 97.644%. The addition of hazelnuts and walnuts did not cause major changes in the content of dry matter. The 50% addition of hazelnuts/walnuts caused a slight increase of dry matter content compared to the 25% addition of hazelnuts/walnuts. However, addition in higher amount caused decrease of the ash and raw fiber content, which can be seen in Table 1. The ash content was similar in all samples, and it was between 2.381% to 2.490%. It is interesting that the muesli bars with the addition of hazelnuts had much higher raw fiber content compared to the muesli bars with the addition of walnuts. That happened because 100 g of hazelnuts contains 10 g of raw fibers compared to the 100 g of walnuts, which contains 5 g of raw fiber [29].

**Table 2.** Dry matter, ash and raw fiber content in muesli bars

| Sample | Dry matter content (%) | Ash content (%) | Raw fiber content (%) |
|---|---|---|---|
| 25% of hazelnuts | 96.784 | 2.468 | 7.067 |
| 50% of hazelnuts | 97.688 | 2.381 | 6.966 |
| 25% of walnuts | 97.360 | 2.490 | 2.690 |
| 50% of walnuts | 97.644 | 2.407 | 2.390 |

Addition of hazelnuts/walnuts in higher amount caused a decrease of total and reduced sugars content compared to the 25% addition. The reduction was approximately 3%. The sucrose content was about the same in all the samples because all the sucrose came from honey which was used in the same amount for all formulations, which can be seen in Table 3.

**Table 3.** Total sugars, reduced sugars and sucrose content in muesli bars

| Sample | Total sugars content (%) | Reduced sugars content (%) | Sucrose content (%) |
|---|---|---|---|
| 25% of hazelnuts | 14.000 | 11.600 | 2.280 |
| 50% of hazelnuts | 11.000 | 7.600 | 3.230 |
| 25% of walnuts | 13.400 | 10.000 | 3.230 |
| 50% of walnuts | 10.000 | 6.200 | 3.610 |

No fat was added during the preparation of the muesli bars. All of the fat came from the used seeds and hazelnuts/walnuts. Addition of hazelnuts/walnuts in higher amount caused an increase of fat content and a decrease of protein content compared to the 25% addition, which can be seen in Table 4.

**Table 4.** Fat and protein content in muesli bars

| Sample | Fat content (%) | Protein content (%) |
|---|---|---|
| 25% of hazelnuts | 24.888 | 25.112 |
| 50% of hazelnuts | 36.432 | 24.340 |
| 25% of walnuts | 33.419 | 27.706 |
| 50% of walnuts | 39.695 | 27.580 |

As was expected drying in food dehydrator caused a slight decrease of total polyphenols and antioxidant capacity. Table 4 shows changes in the amount of total polyphenols and antioxidant capacity before and after drying. Addition of hazelnuts/walnuts in higher amount caused an increase of total polyphenols and antioxidant capacity compared to the 25% addition. The highest total polyphenols and antioxidant capacity was in the dough with 50% of walnuts. As for the product itself, the highest polyphenols content and antioxidant capacity was in the muesli bar with 50% of walnuts, which can be seen in Table 5.

**Table 5.** Total polyphenols content and antioxidant capacity in dough and muesli bars

| Sample | Total polyphenols content (mg/L) | Antioxidant capacity (mmol/L) |
|---|---|---|
| Dough - 25% of hazelnuts | 205.481 | 3428.333 |
| Muesli bar - 25% of hazelnuts | 107.333 | 3169.167 |
| Dough - 50% of hazelnuts | 331.901 | 4761.667 |
| Muesli bar - 50% of hazelnuts | 115.728 | 3425.000 |
| Dough - 25% of walnuts | 188.198 | 5263.333 |
| Muesli bar - 25% of walnuts | 173.753 | 4644.167 |
| Dough - 50% of walnuts | 877.086 | 6501.667 |
| Muesli bar - 50% of walnuts | 486.716 | 5084.167 |

As shown in Table 6, total sensory score was similar in all samples, and it was from 43.666 to 47.223. The muesli bar with the 25% of walnuts has had the highest sensory score, and the lowest goes to the muesli bar with the 50% of walnuts. All of the muesli bars were good graded. In general, the addition of 50% of hazelnuts or walnuts caused a decrease in sensory properties compared to the addition of 25%.

**Table 6.** Results obtained by sensory analysis of muesli bars samples (DLG method)

| Graded property | 25% of hazelnuts | 50% of hazelnuts | 25% of walnuts | 50% of walnuts |
|---|---|---|---|---|
| **shape, color, surface** | 4.778 | 4.000 | 4.889 | 3.667 |
| **hardness, structure** | 14.000 | 12.667 | 14.000 | 12.333 |
| **chewiness** | 15.000 | 14.333 | 14.667 | 14.333 |
| **odour** | 6.000 | 6.1667 | 6.500 | 6.500 |
| **taste** | 7.167 | 6.500 | 7.167 | 6.8333 |
| **Total score** | **46.945** | **43.667** | **47.223** | **43.666** |

## CONCLUSION

Muesli bars can be made under minimal thermal treatment. Different seeds in combination with walnuts and hazelnuts represent a very good base for production of the muesli bars. All of these ingredients improve nutritive and sensory properties. The dry matter content was similar for all samples, within the expected range and appropriate values. The ash content was similar for all samples. The raw fiber content for the muesli bars made with hazelnuts was significantly higher than for the crackers with walnuts. Addition of hazelnuts/walnuts in higher amount caused a decrease of total and reduced sugars content compared to the 25% addition. The sucrose content was about the same in all the samples. Addition of hazelnuts/walnuts in higher amount caused an increase of fat content and a decrease of protein content compared to the 25% addition. Dough and muesli bar with 50% of walnuts had the highest total polyphenols content and antioxidant capacity, and the lowest results were obtained for dough and cracker with 25% of hazelnuts. The highest total sensory score was in muesli bar with 25% of walnuts. It can be concluded that the addition of 50% of hazelnuts or walnuts caused a decrease in sensory properties compared to the addition of 25%. However, all four muesli bars were good graded.

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