FORTIFIED CHOCOLATE SNACKS WITH INCREASED LEVEL OF IRON

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Abstract
Iron deficiency is a common problem especially among children, women of reproductive age and sportsmen. Addition of highly bioavailable iron to foods could be one possibility to enrich daily diet and increase iron absorption.
At present moment, there is a limited number of fortified products with iron in the market. Fortification of common food products is an effective strategy to prevent or overcome iron deficiency. The results show a significant increase of iron in products supplemented with bovine alimentary albumin. Comparing fortified products with non-fortified control samples of chocolate snacks the iron content increased from (1.17 – 2.61) to (10.15 − 11.53) mg 100 g^{-1} in products supplemented with bovine alimentary albumin. By developing a successful recipe of fortified food products, animal origin heme iron could be applicable component and satisfy sensory acceptability from consumers.
The aim of this work was to create an alternative sweet product as healthy snack with incorporated highly bioavailable heme iron which may be an addition to daily diet with nutritional properties and accepted by consumers.
Key words: fortified foods, iron deficiency, heme iron.

Introduction

Iron deficiency is the most common mineral deficiency affecting an estimated quarter of world's human population (WHO, 2015). It is one of the leading risk factors for disability and death worldwide (Zimmermann & Hurrell, 2007). Iron deficiency is especially widespread among children, women of reproductive age and sportsmen (Srdjan, Mukesh, & Agarwal, 2007). Iron deficiency or anaemia as its severe form develops after prolonged deficit of iron. If not for other reasons such as genetic illnesses or injuries, it is mainly due to insufficient iron absorption (Hurrell & Egli, 2010). There are two forms of dietary iron in the human diet: non-heme iron and heme iron. The first one is broadly present mostly in plants, whereas heme iron is found in foods derived from animal tissues (Sharp & Srai, 2007). Notwithstanding that there is an abundant amount of non-heme iron obtained from plant origin food products in our diet, only 2% – 15% of that is absorbed in human organism. It is due to phytates and polyphenols present in plants, which works as a strong inhibitor of non-heme iron (Hurrell & Egli, 2010). Poor absorbance is the main reason of iron deficiency. Whereas heme iron has high bioavailability of absorption (15%−35% absorbed) and is not affected of any other inhibitors except calcium which inhibits both types of iron (Abbaspour, Hurrell, & Kelishadi, 2014). Iron bioavailability can be enhanced when ingested in the presence of foods with high levels of ascorbic acid, fruit acids, fructose and muscle tissues (Pizarro *et al*., 2016; Christides & Sharp, 2013; Bæch *et al*., 2003). Based on studies, it is determined that heme iron absorption increases when ingested as haemoglobin. Several studies compare iron bioavailability of different food sources and describe effects (Eisenstadt *et al*., 2013). The major issue is to obtain a positive long term health effect from available food products. Fortified foods with high level of bioavailable iron may be used as one of tools (Alemán *et al*., 2016; Rebellato *et al*., 2015).

Candies are popular and preferably consumed food items all over the world. There are many types of candies and each market differs with assortment depending on consumers' preferences, country's cultural and traditional factors, season of the year, etc. In traditional sweet manufacture, locally available products are used as classic ingredients. Fruits are considered healthy, and besides their pleasant flavour and taste there are numerous beneficial components they provide and enrich human diet. They are sources of essential vitamins, minerals, biologically active compounds and dietary fiber. What is more, heme iron absorption is not affected by fruit compounds and therefore may be consumed in the same meal. In many countries locally grown fresh fruits are available short period of the year due to their characteristic seasonality; therefore, there are adapted different methods and technologies for fruit preservation. As one of the common methods used is fruit dehydration. If drying method applied is delicate, fruits may preserve their vitamins, minerals and other bioactive compounds with smaller scale of losses (Sagar & Suresh, 2010).

Chocolate confectionery forms a great part of the sweet's market and incorporates diverse products. Continuous development of chocolate containing products is the result of manufacturers' creativity and market demand. In general, certain food products especially confectioneries have a negative reputation for their high calorific value what is the main reason for obesity and diverse health issues. Concerning this fact, market should provide more products with additional nutritional value which besides the good taste ensure functional properties.

Confectionery based food supplements are highly acceptable products providing good taste and necessary compounds. Such products are easy to incorporate in daily diet for consumers of all ages. Regarding fortified sweets with iron, there is a very poor selection in the market. In Latvia such products available are toffees supplemented with bovine alimentary albumin (heme iron). The product traditionally is named 'Hematogen' and produced by companies in Lithuania, Belarus and Russia. The amount of iron in these products is around 70% of Recommended Daily Intake in 100 g of product. Recommended Daily Amount of Iron is 14 mg (Directive 2008/100/EC, 2008).

The aim of this work was to create an alternative sweet product as healthy snack with incorporated highly bioavailable heme iron which may be an addition to daily diet with nutritional properties and accepted by consumers.

Materials and Methods

For fruit snack production dried fruits, berries, nuts and seeds were chosen with focus on the use of locally cultivated products. Fruit seeds and nuts in packs were purchased from the wholesale store Ltd. 'Gemoss' in Latvia. Dry marc of pumpkins and red beetroots were obtained in the frame of AgroBioRes project. Extra dark chocolate with cocoa solids 70% (cocoa mass, sugar, low fat cocoa powder, cocoa butter, emulsifier ammonium phosphatide, flavouring) was chosen from the manufacturer Ltd. 'Laima' (Latvia). Spray-dried bovine blood alimentary albumin as a source of iron for products' supplementation was imported from Lithuania. The list of ingredients used in each recipe of snacks is shown in Table 1. The amount of ingredients was chosen to make suitable texture for shaping candies, as well as satisfy sensorial criteria.

All ingredients except chocolate and bovine alimentary albumin were prepared by grinding, crushing and cutting. Then, ingredients for each product shown in Table 1 were mixed together till uniform mass and from ready mixture by hands made the shape of small balls with weight of 7 ± 0.2 g each. The chocolate was melted in water bath at +43 ± 2°C. For bath of chocolate intended for use in

Table 1

Ingredients used in each recipe of snacks

Code of product	Ingredients	% of total product
1	Prunes (dry) Sunflower seeds (dry) Chocolate Blackcurrants (dry)	31 29 23 17
1F	Prunes (dry) Sunflower seeds (dry) Chocolate Blackcurrants (dry) Bovine alimentary albumin (iron)	31 29 19 17 4
2	Cranberries (dry) Hazelnuts (dry) Chocolate Redcurrants (dry)	38 23 23 16
2F	Cranberries (dry) Hazelnuts (dry) Chocolate Redcurrants (dry) Bovine alimentary albumin (iron)	38 23 19 16 4
3	Japanese quinces (candied) Pumpkin seeds (dry) Chocolate Pumpkin (dry marc)	46 23 23 8
3F	Japanese quinces (candied) Pumpkin seeds (dry) Chocolate Pumpkin (dry marc) Bovine alimentary albumin (iron)	46 23 19 8 4
4	Apples (dry) Chocolate Beetroots (dry marc)	65 23 12
4F	Apples (dry) Chocolate Beetroots (dry marc) Bovine alimentary albumin (iron)	65 19 12 4

iron supplemented products, the melted chocolate was chilled to +38 ± 0.5 °C and then bovine alimentary albumin was added. The temperature is crucial as to avoid protein denaturation and losses of iron of bovine alimentary albumin. Chocolate mixture was thoroughly stirred to ensure even incorporation of added ingredient. Ready fruit snacks were covered with chocolate to form a glaze and left to cool in refrigerator at +8 ± 0.5 °C.

Samples without added bovine alimentary albumin (1, 2, 3, and 4) were used as control to compare the differences between products. For the same products with incorporated bovine alimentary albumin the code includes ‘F’ (1F, 2F, 3F, and 4F) as shown in Table 1.

Atom-absorption-spectrometer Perkin Elmer Analyst 800 was used for iron determination in fortified chocolate snacks and control samples. Procedure was done according to LVS EN 14082 method.

pH was measured with pH-meter Jenway 3520 pH Meter (Jenway, AK). pH-meter calibration was done with pH standard solutions 4.01 and 7.00. 5.00 g of each sample was mixed with 50 ml of distilled water and mixed on magnetic stirrer 20 min. After that, pH was measured for five repeats of each product.

Moisture of products was determined using a moisture analyser Precisa XM 120. 2 g of product was used for each measure under 105 °C temperature.

Water activity was determined by LabSwift-aw (Novasina). 6 g of sample was put in a cup and placed in apparatus, then, results were recorded. Temperature during measurement was 22.2 °C.

The colour parameters of ready fruit snacks were measured in CIE L*a*b* colour system by direct reading using Colour Tec – PMC. For getting results, the following colour parameters were evaluated: brightness (L*) ranging from 0 (black) to 100 (perfect white); green-red saturation index (a*); and blue-yellow saturation index (b*) (Papadakis *et al.*, 2000). Before measuring, snacks were cut in half and measures were taken from the core of product and from surface, to determine the colour parameters of chocolate glaze. Colour was measured more than ten times at randomly selected spots for five samples of each variety.

Colour difference (ΔE*) between chocolate glaze without and with added bovine alimentary albumin was calculated using the mathematical equation 1:

$$\Delta E^* = \sqrt{(L^* - L_0^*) + (a^* - a_0^*) + (b^* - b_0^*)}, \quad (1)$$

where ΔE* – colour difference;
L*, a*, b* – values for chocolate with bovine alimentary albumin;
L_0^*, a_0^*, b_0^* – values for chocolate without bovine alimentary albumin.

All obtained data were analysed with correlation, ANOVA, using Microsoft Excel 2014. Data Analysis, confidence level was 95% (α = 0.05).

Results and Discussion

Iron content in products is shown in Figure 1.

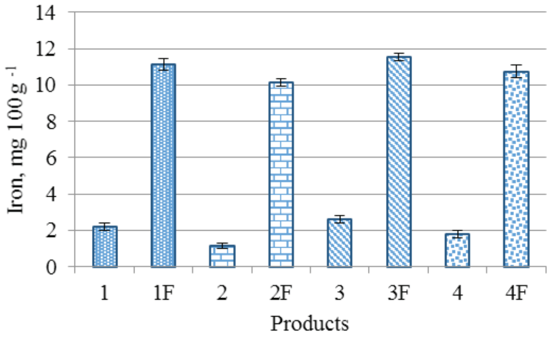

Figure 1. Iron content in products.

Comparing samples without added bovine alimentary albumin, there is no significant difference (p>0.05) between samples – the product 3 contains the highest amount of iron 2.6 ± 0.2 mg 100 g^{-1}. After that follows samples 1, 4 and 2 with 2.2 ± 0.2, 1.8 ± 0.2 and 1.2 ± 0.2 mg 100 g^{-1} respectively that could be explained with ingredients in products, as pumpkin and sunflower seeds contain higher amount of iron comparing to other products’ ingredients used. Products with added bovine alimentary albumin follow the same order, as control samples. Addition of bovine alimentary albumin significantly (p<0.05) increases the content of iron in product reaching 11.6 ± 0.2 (sample 3), 11.1 ± 0.3 (sample 1), 10.8 ± 0.3 (sample 4) and 10.2 ± 0.2 (sample 2) mg 100 g^{-1} respectively was observed.

Figure 2 shows pH level of fortified chocolate snacks and control samples.

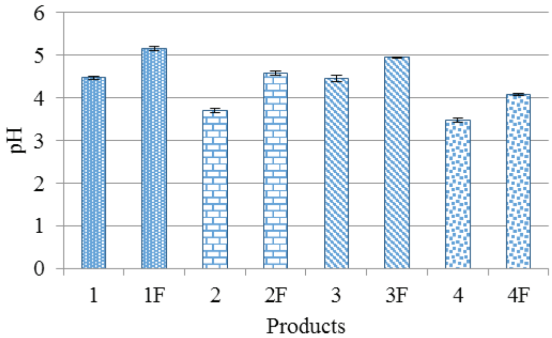

Figure 2. pH of products.

The most acidic product is of the 4th sample with pH 3.5 ± 0.02 which consists of apples, then follows the sample 2 made of cranberries and red currants.

Difference between the sample 1 and 3 is negligible ($p>0.05$). The results of pH reveals as significant ($p<0.05$) increase in value in all supplemented products and such a rise is likewise detected by other authors (Quintero-Gutiérrez, *et al.*, 2012; Yousif, Cranston, & Deeth, 2003). That is due to bovine alimentary albumin additive which had been obtained from bovine blood and had pH 7.5 ± 0.02 what is usually detected pH level for dried bovine blood (Cingi *et al.*, 2009).

In Figure 3, the obtained moisture level results of investigated products are shown. Samples of products were obtained after uniform mixing of the whole chocolate snack, so samples had parts of chocolate glaze and fruit filling.

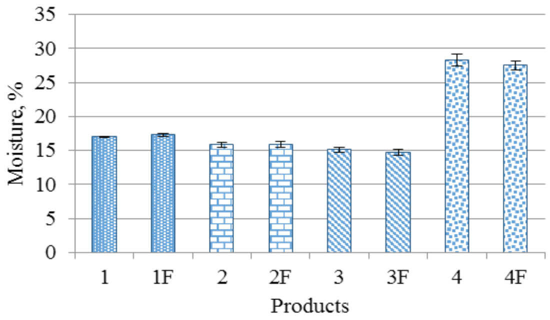

Figure 3. Moisture of products.

Comparing all results, the largest moisture content is in product 4, 4F samples (28.9 ± 0.5% and 27.52 ± 0.4%) which consist of apples and beet. The moisture content between 4, 4F samples and moisture of other products is significant ($p<0.05$). That is due to a high level of moisture of dried beet and apples which was suitable to make a sticky mixture suitable to form snack balls as more dried products failed in shaping. The moisture level comparing between products without and with bovine alimentary albumin is close; therefore, one can assert that composition of chocolate glaze does not influence total moisture of a whole product.

Water activity in products is moderately similar – the lowest result was determined in sample 2F (0.68 ± 0.02), but the highest – in sample 4 reaching 0.83 ± 0.04 (Fig. 4). In addition, no significant difference between samples without and with bovine alimentary albumin was observed.

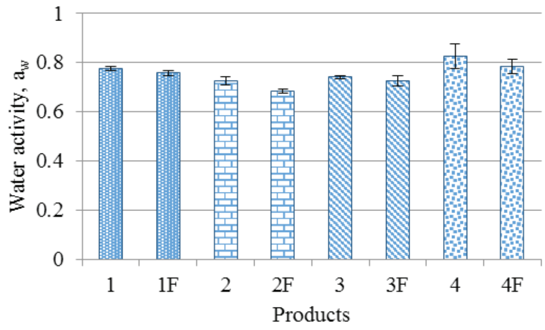

Figure 4. Water activity of products.

Colour is an important attribute in food as it gives the first impression about product and usually is critically evaluated by consumers. For colour evaluation, the surface of products as the iron supplement was incorporated only in chocolate glaze was used; therefore, the changes of colour of inside filling were not affected. The initial L*, a*, b* values describing colour differences of investigated samples' chocolate glaze with and without additional iron are shown in Table 2.

Chocolate glaze with bovine alimentary albumin was darker resulting in lower L^* values (20.6 ± 0.3). Similar results were reported by Yousif, Cranston, & Deeth (2003) using bovine blood components in food production. Addition of iron changes green-red and blue-yellow saturation in chocolate as obtained a* and b* values decrease. The calculated value for total colour change (Δ E*) in chocolate without and with iron supplement is 3.5.

Conclusion

The addition of bovine alimentary albumin is effective supplement for incorporating into foodstuff thus significantly increasing iron content. Products made in this project with additional bovine alimentary albumin have higher pH and darker colour, what is usually determined and reported properties using bovine blood components in food production. Further research is needed to determine sensory acceptability of product and other physical and chemical measurements. Additionally, shelf life and storage conditions for products must be observed.

Table 2

Colour components in chocolate glaze

Type of glaze	L*	a*	b*	Δ E*
Chocolate	27.8 ± 0.6	3.7 ± 0.5	6.6 ± 0.3	3.5
Chocolate with bovine alimentary albumin	20.6 ± 0.3	1.9 ± 0.3	3.3 ± 0.3	

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