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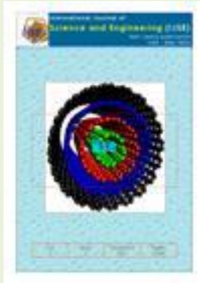

Physicochemical Properties of Baby Instant Porridge Fortified with Iron

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Abstract - *Fortification is one of solution to alleviate iron deficiency. Prevalence of iron deficiency anemia mostly on children under five years, i.e baby instant porridges. Purple sweet potatoes have a potential to be baby instant porridge. The aims of this research was to investigate the effect of fortificant's type on Fe level as nutritional value, physicochemical properties (bulk density, rehydration capacity, and color) of baby instant porridges made from purple sweet potatoes. This study consists of several stages, which are the stage of making flour, fortification, instant porridge production and analyses stage. The results show that iron-fortified added to instant baby porridge for nutritional characterization is below to the concentration of additional fortificant. The higher Fe identified on the addition of the iron concentration of 90 ppm (76.12 ppm) and lowest for the addition of concentration of 70 ppm (32.14 ppm). The results of physical properties for bulk density of instant porridge showed there was not significant difference between variables. Rehydration capacity with the addition of the iron various variable does not provide significant value changes and provide a lower value than the baby porridge with no fortificant.*

Keywords— *iron fortification, baby instant porridges, physicochemical properties*

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I. Introduction

Anemia is the most common blood disorder and also a public health problem globally. It most suffering people in the developing countries. The general cause of anemia is iron deficiency. Iron deficiency anaemia has serious functional consequences, as well as negative economic consequences in countries where it is a major health public problem. Iron deficiency anaemia is found to be associated with negative affect on physical growth, mental development, impaired cognitive development of young children, reduced work capacity in adults, an increased risk of maternal and neonatal mortality and premature birth, and altered immune function (Tripathi *et al*., 2012; Baltussen *et al*., 2004). The prevalence of IDA in Middle east region is about 63% of the preschool children and the rest among adolescents and pregnant women (Al-Zabedi *et al*., 2014).

Some strategies have been conducted to alleviate iron deficiency in people society, including supplements production, dietary modification, and micronutrient fortification (Handayani *et al*., 2014; Prom-u-thai *et al*., 2010; Cakmak, 2008). Supplementation is not effective in long term, while dietary modification may increase iron level, but it needs nutrient expertise and the effectiveness rely on season changes and other agronomic practices (Prom-u-thai *et al*., 2010). Fortification is an effective method that can be used to overcome micronutrient deficiencies. In children under five years, iron fortification can be carried out on baby instant porridge as complementary feeding. Commonly, baby porridge is made up from rice flour, skim milk, and sugar. Purple sweet potatoes (Ipomoea batatas L.) is one of local commodity that have high nutritional value. They are particularly rich in beta carotene and anthocyanin. This anthocyanin provide pharmaceutical properties such as free radical scavenging characteristic (Peng *et al*., 2013). Potatoes can be converted into flour as an intermediate product. Therefore, it also has a potential to replace the use of rice flour as baby foods.

Many researches have been conducted to investigate the effectiveness of fortification (Handayani *et al*., 2014; Wei *et al*., 2013; Hei *et al*., 2013; Akhtar *et al*., 2011). Based on author's knowledge, study of iron fortification on purple sweet potatoes flour to produce a baby instant porridge has never been done before. A successful food fortification program includes the use of soluble iron such as ferrous sulfate, the addition of ascorbic acid as an absorption enhancer or the use of NaFeEDTA to overcome the negative effect of phytic acid. Better absorbed alternative compounds for cereal fortification include encapsulated ferrous sulfate and NaFeEDTA .The aims of this research was to investigate the effect of types of fortificant type (FeSO4 and NaFeEDTA) on Fe concentration as nutritional value, physical properties (bulk density, rehydration capacity, color, and structure) of baby instant porridges made from purple sweet potatoes.

II. MATERIAL AND METHOD

Raw material

Purple sweet potato obtained from local market in Indonesia, demineralized water, sodium bisulfite $FeSO_4.7H_2O$ (p.a)and NaFeEDTA (p.a).

Preparation of Purple Sweet Potato Flour

Purple sweet potato peeled, washed with water, sorted the good quality, then thinly sliced to a thickness of ± 1mm, soaked in 0.3% Sodium Bisulfite solution for 1 hour to prevent browning, then dried at temperature 60 °C for 20-22 hours using oven, then reduced it size using grinder to obtain a powder and sieved to 40-60 mesh.

Fortification of Purple Sweet Potato Flour

Fe fortification was done using mixing and agitation process. The flour is then added a fortificant $FeSO_4.7H_2O$, NaFeEDTA with predetermined variables (50 ppm, 70 ppm, 90 ppm, 110 ppm). First fortificant dissolved in 100 ml of free mineral water so obtained flour ratio : 1:1 for flour-demineralized water. Then put into the stirred tank until the mixture becomes homogeneous and form a slurry. The slurry was dried using a oven with a temperature of 60 °C for 5 hours.

Baby Instant Porridges Production

The slurry was dried using an oven with temperature of 60 °C for 5 hours. Results are drying flake further sieved with 60 mesh sieve. Flake when added to hot water (60 ° C -70 ° C) will be a instant porridge.

Analysis

Fe Concentration

The flour sample was charred and then ashed in a muffle furnace at 550 C for 6 h and the ash was dissolved in concentrated hydrochloric acid. Total iron content was analyzed using atomic absorption spectrometer (Shimadzu AAF-6701).

Color

The colour of instant porridge was measured using Chromameter CR-400 (Minolta). The asparagus slices were milled in a coffee grinder to obtain fine powder. The analyses of the colour values were done three times for each sample. Three parameters, L* (lightness), a* (redness), and b* (yellowness), were used to study the changes in colour L* refers to the lightness of the samples and ranges from black = 0 to white = 100. A negative value of a* indicates green, while a*positive one indicates red-purple colour. A positive b *indicates yellow colour and a negative one blue colour. The hueangle, defined as h° = tan–1 (b/a), was calculated from a* and b* values and expressed in degrees: 0° (red), 90° (yellow), 180° (green), 270° (blue).

Rehydration capacity

The rehydration capacity was used as a quality characteristic of the dried product. Approximately 2 g (± 0.01 g) of the dried sample was placed in a 250 ml laboratory glass (two analyses or each sample), 150 ml distilled water was added and the glass was covered and heated to boil within 3 minutes. The content of the laboratory glass was then gently boiled for 10 more min and then cooled. The cooled content was filtered for 5 min under vacuum and weighed. The dehydration ratio was calculated as:

$$RC = \frac{W_R}{W_d} \times 100\%$$

where:

Wr – drained weight (g) of the rehydrated sample

Wd– weight of the dry sample used for rehydration

Scanning electron micrographs (SEM)

Microstructure of baby instant porridges samples was observed using a scanning electron microscopy (S-4800 scanning electron micrograph, Hitachi High Technologies Corporation, Tokyo, Japan)

Dissolution time

Dissolution time, a time for baby instant porridge sample dissolves completely in water, was determined by measuring the time for complete dissolution in water at temperatures of 70°C using glass reactor.

III. RESULT AND DISCUSSION

Fe Level of Baby Instant Porridge

Fe analysis was conducted on baby instant porridge using Atomic Absorption Spectrophotometer (AAS). Table 1 represents of Fe level on baby instant porridge fortified FeSO4 and NaFeEDTA. In general, Fe fortification on baby instant porridge in the mixing and agitation process increased Fe concentrations in both fortificant types, compared with unfortified porridges. In the other hand, some treatment shows that there is also Fe concentration were missing. The highest amount of Fe unidentified is 65.70% which is obtained from the addition of FeSO4 70 ppm. The most effective fortification with the minimum Fe loss is achieved on 50 ppm NaFeEDTA augment.

Loss of iron concentration on both types of fortificant might be caused by low of Fe uniformity in every point. An amount of matter may be called uniform or homogenous when the composition of an element of volume of appropriate size does not deviate by more than a fixed amount from the average composition of the entire system. Furthermore, there are parameters that greatly influence the mixing efficiency and uniformity systems, such as mixing time, presence of baffle, component concentration, pattern of initial loading, filling rate percentage, blender geometry, and use of pre-mixing (Zhou *et al*., 2016). Baffles in the mixing system not only increase particle velocity, but also disturb particle convection and diffusion in the flowing layer (Hanada *et al*., 2015). Therefore, advance researches to investigate parameter systems that can enhance mixing and agitation performances are needed.

Table1. Fe concentration on baby instant porridge

Types of fortificant		Fe detected (ppm)	% Loss
nfortified porridge	-	23,07	-
$FeSO_4$ (ppm)	50	41.66	43.48
	70	32.14	65.70
	90	76.12	33.05
	110	56.40	57.82
NaFeEDTA (ppm)	50	78.43	7.33
	70	85.58	8.05
	90	87.78	22.37
	110	56.97	57.19

Table2. L, a, b colour of baby instant porridge purple sweet potato

Sample		1st test	2nd test	3rd test	Average
Unfortified porridge	L	59,55	58,82	59,37	59,247
	a	12,57	12,63	12,94	12,713
	b	-2,01	-2,01	-2,03	-2,017
$FeSO_4$ 90 ppm	L	58,98	59,93	60,24	59,717
	a	6,19	5,95	6,08	6,073
	b	-3,38	-3,31	-3,41	-3,367
NaFeEDTA 90ppm	L	58,78	58,32	57,72	58,273
	a	7,42	6,82	7,15	7,13
	b	-3,46	-3,42	-3,43	-3,437

Description :
L (lightness) = black to white (0 tp 100)
a (red – green) = positives values are red; negative values are green, 0 is neutral
b (yellow – blue) = positives values are yellow; negative values are blue, 0 is neutral

Physical Properties of Instant Porridge

Colour

Colour analysis was carried out by using Minolta CR-400. Baby instant porridge fortified with iron had lower “a” values, and no significant differences in “L and b” values compare with unfortified porridge (Table 2). Thus, the amount of iron increased the porridge became lightness, less red, and more blue. In general, fortification process resulted in darker products, probably due to oxidation reaction by iron addition. Many iron compounds are colored and cannot be used to fortify light-colored foods. Ferrous sulfate (FeSO4), water-soluble compounds, promote fat oxidation and reduce product shelf life, otherwise it can make product discoloration (He *et al*., 2013; Akhtar *et al*., 2011). FeEDTA is a pale yellow water-soluble powder which has a high stability and does not make a crucial problem and can serve as a vehicle for fortification (Akhtar *et al*., 2011).

Bulk Density

Figure 1 shows the effect of fortificant concentraion on both fortificant types to bulk density of instan porridges. Bulk density value of products ranged from 0.781 to 0.874 g/ml. There was no significant difference value of bulk density on iron addition. Instant porridge fortified with iron represented no clear trend and had minimal effect on bulk density of unfortified porridges. The maximum value was obtained by 50 ppm FeSO4 addition, while minimum achieved by 90 pp, NaFeEDTA augment. These patterns were also similar to other reported zinc fortification of instant porridge (Handayani *et al*., 2014).

The bulk density of a powder food is the ratio of the mass of an untapped powder sample and its volume including the contribution of the interparticulate void volume (Peleg 2014). It depends on both the density of powder particles and the spatial arrangement of particles in the powder bed. The bulk density is expressed in grams per millilitre (g/ml) although the international unit is kilogram per cubic metre (1 g/ml = 1000 kg/m3) because the measurements are made using cylinders. High bulk density is also a proper characteristic of food for it’s importants nutrients value and ease packaging (Parvin *et al*., 2014; Mohammed *et al*.,2011; Shittu *et al*., 2005). Baby’s foods should have minimum bulk with high bulk density value due to baby’s stomach capacity is still limited so that nutritional intake are met (Parvin *et al*., 2014). Moreover, baby instant foods fortified with iron provides higher bulk density value compare to commercial products of baby porridge (0.40 to 0.49 g/ml).

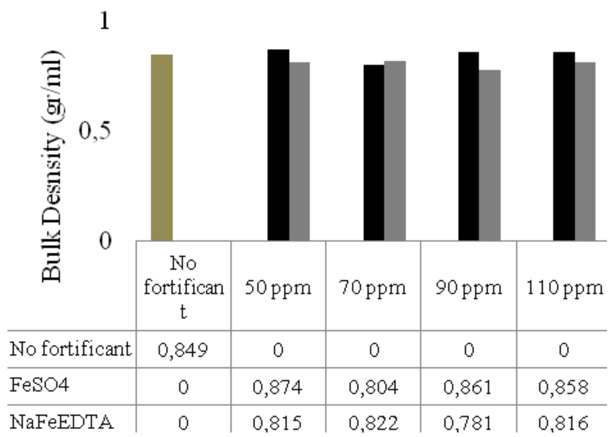
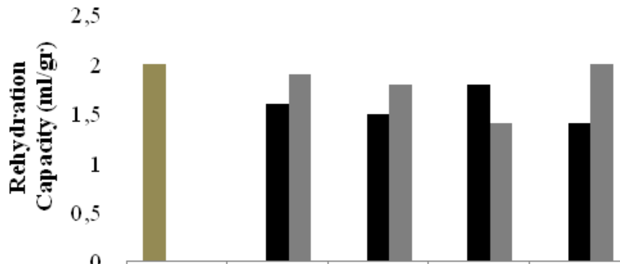


Figure 1. Bulk density of instant baby porridge by fortificant type

Rehydration Capacity

The quality of dried foods is dependent in part on changes occurring during processing and storage. Some of these changes involve modification of the physical structure. The most commonly nature in determining quality of dried food is rehydration properties. Rehydration capacity of instant porridges indicates the capacity of dried material to absorb water and to hold soluble solids inside dried matrix. Figure 2 represents the result on rehydration capacity of baby instant porridges at different types of fortificant. Rehydration of products ranged from 1.4 to 2.0 ml/gr. There was no significant difference value of rehydration on iron augment. Instant porridge fortified with iron represented no clear trend and had minimal effect on rehydration of unfortified porridges (2.0 ml/gr). The minimum rehydration capacity (1.4 ml/gr) obtained by addition of 110 ppm FeSO4, in the other hand the maximum rehydration capacity (2.0 ml/gr) achieved 90 ppm NaFeEDTA augment.

Rehydration is characteristics affected by several factors, such as product chemical composition, drying techniques and conditions, composition of the immersion medium, and temperature (Taiwo and Adeyemi, 2009). These fact is different from the research result conducted by Handayani (2014). Zinc fortification could enhance the rehydration capacity of instant porridges compare with unfortified porridges. This distinction is very possible because the type of minerals were added different.

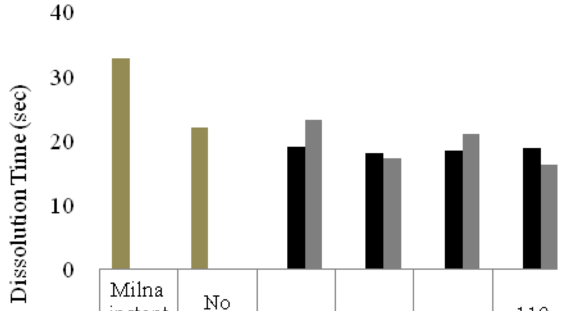


	No fortificant	50 ppm	70 ppm	90 ppm	110 ppm
No fortificant	2	0	0	0	0
FeSO4	0	1,6	1,5	1,8	1,4
NaFeEDTA	0	1,9	1,8	1,4	2

Figure2. Rehydration capacity of instant baby porridge

Dissolution time

Instant food is identical to its easy serve and it requires a relatively short time. One of the criteria for a good instant product properties determined by wetting the exact time that must be down (sink without clumping). The terms refer to the time of rehydration of instant porridge. Figure 3 shows the results of dissolution times of instant porridges. In general, both porridges with iron addition had lower dissolution time in compare with unfortified (22.05 sec) and commercial instant porridge (32.85 sec). Times for porridge fortified with FeSO4 sample dissolving completely in water are faster than time for porridge fortified with NaFeEDTA (Akhtar *et al*. 2011). Iron sulfate (FeSO4) includes the groups of soluble iron, in order that it can also increase the solubility of that instant porridge than NaFeEDTA. Porridge's structures fortified with iron might be more porous so that it can absorb more water than unfortified porridge.

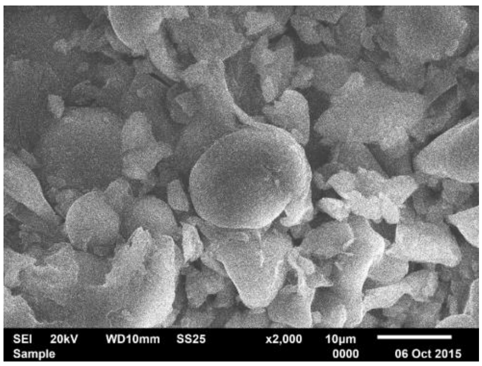


	Milna instant porridge	No fortificant	50 ppm	70 ppm	90 ppm	110 ppm
No fortificant	32,85	22,05	0	0	0	0
FeSO4	0	0	18,93	18,03	18,48	18,81
NaFeEDTA	0	0	23,2	17,15	21,04	16,24

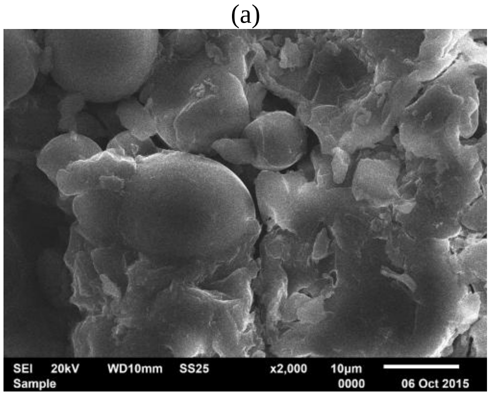
Figure3. Dissolution time of instant baby porridge

Microstructures

Microstructures of baby instant porridges samples observed with Scanning electron microscopy (SEM) indicated the structural difference between samples (Figure 4). Commonly, food products undergo volumetric phase changes upon water loss during dehydration process, especially for fibrous material (meat, fruit, and vegetables) (Khalloufi and Ratti, 2003). Rigid and porous properties were obtained after dehydration process. However, no shrinkage was observed with all of the baby instant porridge. As shown in the SEM images, porridges fortified with iron was more smooth and homogenous with harder texture than that of unfortified porridges. Since instant porridge is consumed after rehydration process, the textural characteristics of instant porridge are less important than the rehydration capacity.



(a)



(b)

Figure 4. SEM micrographs of baby instant porridges with no fortificant (a) and with iron fortification (b)

IV. CONLUSIONS

In general, Fe fortification on baby instant porridge in the mixing and agitation process increased Fe concentrations in both fortificant types, compared with unfortified porridges. The higher Fe identified on the addition of the iron concentration of 90 ppm (76.12 ppm) and lowest for the addition of concentration of 70 ppm (32.14 ppm). The results of physical properties for bulk density of instant porridge are (0.804 to 0.874 g / ml) showed there is no significant difference between variables and iron fortification no significant effect. Rehydration capacity (1.4 to 1.8 ml/g) with the addition of the iron various variable does not provide significant value changes and provide a lower value than the baby porridge with no fortificant (2 ml/g).

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