

Bioavailability of Minerals in Cookies Developed from Blend of Moringa Leaf Powder and Wheat Flour for Iron Deficient Lactating Mothers

Gashaw Muluken Tessera^{1,*}, Abebe Haile², Esayas Kinfe²

¹Hawassa City Administration Natural Resource and Environmental Protection Office, Hawassa, Ethiopia

²Hawassa University, School of Nutrition, Food Science and Technology, Hawassa, Ethiopia

Abstract In this study cookies were prepared from blend of *Moringa stenopetala* leaf powder (MLP) with wheat flour for iron deficient lactating mothers. MLP and wheat flour were blended in the ratio of 0:100, 5:95, 10:90, 15:85 and 20:80 respectively by using mixture simplex lattice design. The main objective of the study was to evaluate the content of Phytate (PA), Tannin, Iron (Fe), Zinc (Zn), Calcium (Ca), Phosphorous (P), and bioavailability of Fe, Zn and Ca in terms of molar ratio in the cookies. The content of Fe (2.87 – 7.77 mg/100g), Zn (0.66 – 1.06 mg/ 100mg), Ca (69.73 – 486.78 mg), P (96.45 – 144.88 mg/ 100mg), Phytate (PA) (53.69 – 114.61 mg/100g) and tannin (9.36 – 66.48 mg/ 100mg) were significantly increased ($P < 0.05$) as the blending ratio of MLP increased. The molar ratios of PA: Ca (0.014 – 0.050) and PA: Zn (7.99 – 11.64) was below the critical values 0.24 and 15.0 respectively while molar ratio of PA: Fe (0.99 – 1.59) was above the critical value 1.0 in all cookies except T₂ (5% MLP) which is 0.99. Hence, Zn and Ca were bioavailable in all cookies while Fe bioavailability was more observed in T₂ (5% MLP) than other treatments. Conception of 100 g cookies per day, satisfy 53.6% of RDA of lactating mothers. In general the study indicated that T₅ (20% MLP blended) contain higher amount of Fe, Zn, Ca and P. However, T₂ (5% MLP) was found to be the best in terms of bioavailability of Fe while Zn and Ca are bioavailable in all treatments.

Keywords Moringa leaf powder, Bioavailability, Iron deficiency, Lactating mothers

1. Introduction

Among the bakery products, cookies are most significant. Cookies are a form of confectionary products usually dried to low moisture content. Compared to biscuit, they tend to be larger with a soft chewing texture. They are consumed extensively all over the world as a snack food and on a large scale in developing countries (29, 30).

Every parts of *Moringa stenopetala* are used for different purposes, mostly providing a highly nutritious food for both humans and animals and medicinal purposes to prevent different diseases. It contains vitamins (A, B, C and E), minerals (Ca, Fe, Zn, P, Cu and others), essential amino acids, essential fatty acids (both omega-3 and omega-6 fatty acids) and phytochemicals [1, 3, 4]. Moringa leaf powder is an excellent nutritional supplement and can be added to any dish to increase macro- and micro-nutrients content of the foods. For healthy individuals, a few spoonful of Moringa leaf powder can be added to any meal to make it more

nutritious. In case of pregnant women and lactating mothers, consuming fresh or dried Moringa leaf powder or pods can improve a mother's health and reduce iron deficiency anaemia. Therefore, consumption of Moringa leaves powder (MLP) by adding to any dish has a potential to prevent a problems of malnourished population [5, 6].

Bioavailability refers to how well a nutrient can be absorbed by the body and used to reduce micronutrient malnutrition. Minerals bioavailability can be affected by the presence of the anti-nutritional factors such as Phytate, tannins and polyphenols in foods. The two most important techniques used to improve minerals bioavailability are reducing the Phytate content in the foods or adding extra minerals in the fortification and blending process [25, 7]. According to [9] study on iron bioavailability of vegetables indicated that cooking increases iron bioavailability of certain vegetables 2 to 10 times. The cooking enhancing effect can be achieved with different heating processes including boiling, stir-frying and hot-air drying. In the case of fresh Moringa leaves, drying and boiling improve iron bioavailability by 3 and 3.5 times, respectively. Cooking Moringa leaves also raised total available of iron. Absorption of plant-based iron is considered lower than that of iron from meat and it is greatly influenced by the

* Corresponding author:

gasawtese@gmail.com (Gashaw Muluken Tessera)

Published online at <http://journal.sapub.org/food>

Copyright © 2015 Scientific & Academic Publishing. All Rights Reserved

interactions with enhancers and inhibitors. Calcium can inhibit iron absorption when fed as inorganic calcium compounds or when consumed in dairy products such as milk or cheese; the level of inhibition depends on the quantity of calcium consumed [10].

There are many techniques used to determine the bioavailability of minerals in the human body. One of the methods is by measuring the molar ratio of Phytate/minerals in the diet [18]. Most studies agreed to use Phytate / Fe >1 to predict bioavailability of Fe in the diet [21]. The suggested critical values that have been calculated; Phytate / calcium > 0.24 [21], Phytate / Zinc > 15 is associated with reduced zinc absorption and negative zinc balance [8]. However, according to [8] 55% of Zn content of foods is expected to be absorbed if Phytate / Zinc ratio of foods is < 5 (High bioavailability); it would be 35% if the ratio is within the range of 5-15 (moderate bioavailability) and only 15% if it is >15 (low bioavailability). The $[\text{Calcium}] \times [\text{Phytate}] / [\text{Zinc}] > 0.5$ [28]. The main objective of this study was to determine some anti-nutritional factors (Phytate & Tannins), some minerals (Fe, Zn, Ca and P) and their bioavailability for iron deficient lactating mothers.

2. Materials and Methods

2.1. Materials Collection

Fresh *Moringa stenopetala* leaf was harvested in April 2014 from Hawassa city (about 275km south of Addis Ababa, Ethiopia) Betekinet Primary School compound. The species was identified and approved by a reference number of 086923 at Addis Ababa University National Herbarium. Special wheat flour produced by Eshet Flour Factory (located at Hassasa-Bale) and other ingredients were purchased from Hawassa city local markets. The raw materials were transported and cookies preparation was done to Hawassa University, School of Nutrition, Food Science and Technology laboratory. Iron, Zinc, Calcium and Phosphorus contents, anti-nutritional factors (Phytate and tannin) of *Moringa* leaves powder (MLP), wheat flour and developed cookies were analysed at Ethiopian Public Health Institute (EPHI) Addis Ababa, Ethiopia.

2.2. Moringa Leaf Powder Preparation

Moringa stenopetala leaves powder (MLP) was prepared by sorting and cleaning the leaves from any extraneous materials by using tap water and ventilated in a shade area for two days at room temperature. It was dried in an oven at 100°C for 3 hours and powdered by using mortar and pestle. The powdered leaf was sieved to remove unwanted matter by using 710 µm sieves size in a repeated manner to get fine powder. The difference in particle size between the coarse and fine powders (both *Moringa* powder and Wheat flour) was separated by using 250 µm sieves size to become uniformly mix MLP and Wheat flour with other ingredients. The Wheat flour and MLP were packed with HDPE plastic bags and stored in desiccators until baking cookies [10].

2.3. Preparation of Blends

Five different blend proportions including control were premeditated based on simplex lattice design (Design Expert version 6.0.8 software). Out of 8 runs, 5 runs were selected for appropriate formulation of the composite flours as software generated. Blends were prepared using mixtures of wheat flour and MLP in the ratios of 100/0, 95/5, 90/10, 85/15 and 80/20 w/w respectively.

2.4. Ingredients

Commercially available sugar, sunflower oil, water, ginger, baking powder, sodium chloride, vanilla were used for the study. The ingredients ratio in cookies preparation was done according to [15] with some modification.

2.5. Cookies Preparation

Cookies were prepared by the procedure of [22]. After accurate weighing of sunflower oil (30mL), sugar (26 g), Baking powder (1 g), sodium chloride (0.9), Composite flour (100 g), Ginger powder (2.5 g) and vanilla (2mL) were mixed and stirred. The dough was kneaded for 9 minutes and sheeted to a thickness of 0.6 cm and cut using a cookies die of diameter 5.5 cm. Cookies were baked in a pre-heated oven at 180°C for 11 minutes, cooled and evaluated for proximate analysis and sensory characteristics.

2.6. Minerals Analysis

Iron, Zinc and Calcium content of formulated cookies were determined by using flame atomic absorption spectrophotometer (FAAS) (model AA - 300 Plus, Australia) and phosphorus content of formulated cookies was also determined by using UV-Vis Spectrophotometer (DU-64 Spectrophotometer, Beckman, USA) by using the procedure of [2].

2.7. Anti-nutritional Factor Analysis

Phytate content of formulated cookies was determined by using the procedure of [11] and Tannin content of formulated cookies was determined according to the procedure of [13] vanillin- HCl methods.

2.8. Bioavailability Determination

Bioavailability of minerals (Fe, Zn, and Ca) was determined by using the molar ratio of Phytate to minerals (Fe, Zn, and Ca) of formulated cookies [18]. The moles of Phytate and minerals (Fe, Zn and Ca) were determined by dividing the actual weight of Phytate and minerals with their atomic weight or molar weight (Phytate = 660 g/mol, Fe = 56 g/mol, Zn = 65 g/mol, Ca = 40 g/mol). The calculated molar ratios were compared with critical values of Phytate: Calcium > 0.24, Phytate: Iron > 1 (21, 16), Phytate: Zinc > 15 [8] and $[\text{Calcium}] \times [\text{Phytate}] / [\text{Zinc}] > 0.5$ [28].

2.9. Data Analysis

The data were evaluated by analysis of variance (ANOVA)

using SAS software of version 9.1 (SAS Institute Inc. 2003). All the analyses were carried out by replicate and results were expressed as mean standard deviation (SD). Fisher's (LSD) test was used to separate means and the significant was accepted at $P < 0.05$.

3. Results and Discussion

3.1. Minerals Analysis of Cookies

The analysis result of Fe, Zn, Ca, and P in the formulated cookies ranged as 2.87 – 7.77 mg, 0.66 – 1.06 mg, 69.73 – 486.78 mg and 96.45 – 144.88 mg respectively as shown in Table 1. Iron (Fe) and Zinc (Zn) are essential trace elements. Calcium (Ca) and Phosphorus (P) are also very important bone related macro elements in human nutrition (31).

The maximum (7.77 mg) and minimum (2.87 mg) Iron (Fe) content was recorded for the cookies made from 20% MLP blended and control (100% wheat flour) cookies respectively. Statistically significant difference ($P < 0.05$) was observed among the treatments. When the amount of MLP increased in the blending ratio Fe contents of the cookies increased dramatically. This indicated that MLP contained more Fe content than wheat flour.

The finding of this study is in close agreement with the work of [27] for the cookies blended from 0 to 15% of *Moringa oleifera* with wheat flour in the increment of Fe content from 1.9 to 6.23 mg/100g. The formulated cookies also have better Fe content as compared with the work of [34]. The consumption of 100g of MLP blended cookies per day could be estimated to satisfy 53.6 – 86.3% of Fe RDA for lactating mothers (9mg/day) [19]. Iron requirement

during lactation is the sum of the requirement of the mother and that required for making up the iron lost in breast milk. Increase in thin body mass also requires iron, primarily for muscle myoglobin [24].

The minimum and maximum Zn content was recorded for T₁ (100% wheat flour) (0.66 mg) and T₅ (20% MLP and 80% wheat flour) (1.06mg) cookies respectively. Statistically, significant difference ($P < 0.05$) was observed among the formulated cookies. There was an increment of Zn content in the formulated cookies as MLP increased in the blending ratio, this pointed as MLP contains more Zn content than wheat flour. Similar result was observed in the finding of [33] who evaluated the mineral content of cookies developed from blend Wheat-Mungbean flour but the formulated cookies have less Zn content as compared with the work of [34]. The consumption of 100g of MLP blended cookies per day could be estimated to satisfy about 6.1 – 8.8% of Zn RDA for lactating mothers (12 mg/day) [19].

The consumption of these MLP blended cookies may contribute to build up normal growth and neurobehavioral development, immune and sensory function, antioxidant protection and membrane stabilisation. It also contributes to reduce the risk of inborn abnormality, low birth weight and other complications of pregnancy and delivery, such as impaired development and premature delivery [20].

The least and the highest Ca content was recorded for T₁ (control) (69.73 mg) and T₅ (20% MLP) (486.78 mg) respectively. Statistically, significant difference ($P < 0.05$) was observed among the formulated cookies. This dramatic increment of Ca content in the formulated cookies was due to higher amount of Ca in MLP than wheat flour.

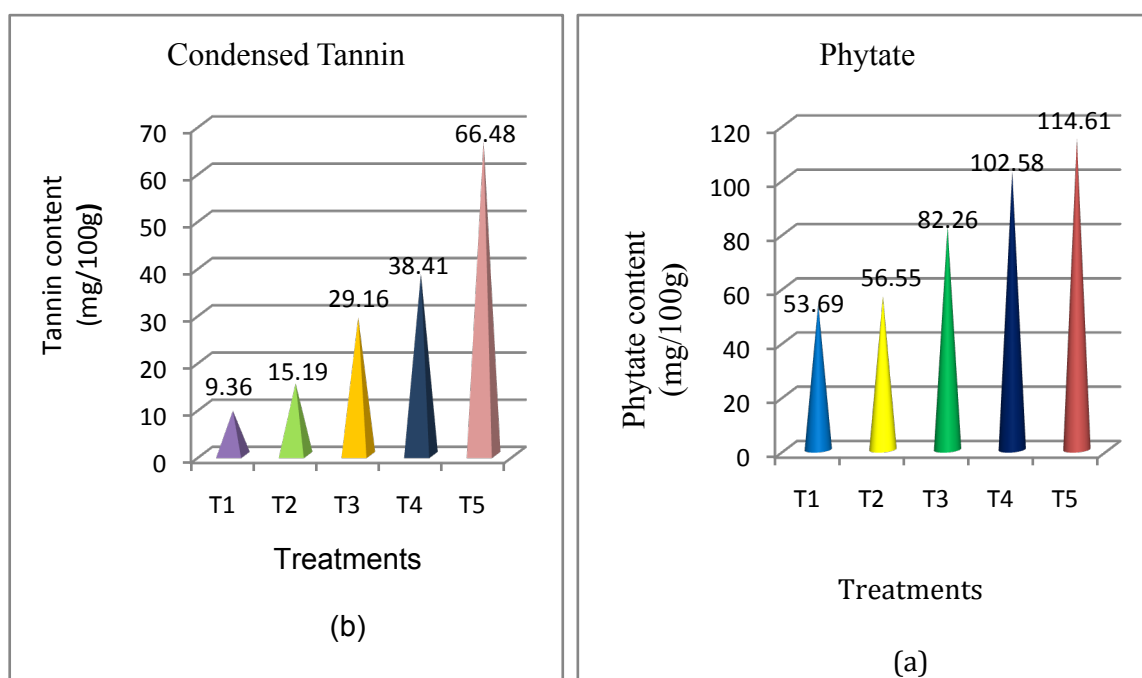


Figure 1. Level of anti-nutritional factors / Phytate (a) and Tannin (b) /of Formulated Cookies

Table 1. Mineral Composition of the Formulated Cookies (mg/100g)

Treatments	Fe	Zn	Ca	P
T ₁	2.87±0.01 ^c	0.66±0.00 ^d	69.73±0.02 ^c	96.45±0.75 ^c
T ₂	4.82±0.02 ^d	0.73±0.00 ^c	211.56±0.34 ^d	112.05±1.13 ^d
T ₃	5.56±0.03 ^c	0.77±0.00 ^c	296.65±2.16 ^c	129.98±0.68 ^c
T ₄	6.28±0.01 ^b	0.87±0.02 ^b	387.98±1.43 ^b	139.00±0.07 ^b
T ₅	7.77±0.01 ^a	1.06±0.05 ^a	486.78±1.56 ^a	144.88±0.04 ^a

Means of the same letter within a column are not significantly different ($P > 0.05$).

T₁ = control, T₂ = 5% MLP and 95% wheat flour, T₃ = 10% MLP and 90% wheat flour, T₄ = 15% MLP and 85% wheat flour T₅ = 20% MLP and 80% wheat flour.

Calcium is required for the normal development and maintenance of the skeleton. Low calcium intake has been associated with loss of bone mass (osteoporosis), resulting in bone fracture in older people, especially women (32). Calcium reserves in bone are affected by dietary calcium intake and calcium losses from the body in different cases, for example lactating mothers supply Ca to their baby during breast feeding. A lactating mother transfers approximately 260 mg per day of Ca to breast milk, this decreased maternal bone Ca flow in the body. She needs additional Ca supplementation in her diets [24]. Hence, this MLP blended cookies expected as good source of Ca and contributes to supply the required amount of Ca to their body during lactation periods. The formulated cookies have better Ca content as compared with the work of [34]. According to [19] report 100 g MLP blended cookies could be estimated to fulfil about 21.2 – 48.7% of the required Ca RDA (1000 mg) for lactating mothers.

The minimum and maximum Phosphorus (P) content was recorded for T₁ (96.45 mg) and T₅ (144.88 mg) cookies respectively. Statistically, significant difference ($P < 0.05$) was observed among the formulated cookies. The increasing of Phosphorus (P) content in the formulated cookies with respect to the level of MLP ratio in the blend was due to high amount of P content in MLP than wheat flour. P is one of important minerals for bone and teeth related nutrients. The MLP blended cookies may satisfy 11.2 to 14.5% of the required P RDA for lactating mothers by consuming 100 g cookies per day; this helps the women to supply the daily required amount of P for her as well as her baby.

3.2. Anti-Nutritional Factors of Cookies

The anti-nutritional factors of formulated cookies such as Phytate (PA) and condensed Tannin were analyzed. Their results were ranged from 9.36 to 66.48 mg/100g and 53.69 to 114.61mg/100g respectively as shown in Figure 1.

The maximum Phytate content was recorded for T₅ (114 mg/100 g) and minimum Phytate content was recorded for T₁ (53.69 mg/100 g). Significant difference ($P < 0.05$) was observed among the formulated cookies. When more MLP was added in the blending ratio, the Phytate content was increased. This may be due to the presence of high amount of Phytate (PA) in MLP than wheat flour. However, the formulated cookies may not be considered as high PA

containing foods. According to [26] report, foods to be considered as high PA containing-foods, it must contain higher than 400 mg PA. Therefore, the PA contents of all cookies are below 400mg. The less PA (56.55 mg/100g) containing cookies among MLP blended cookies was 5% MLP blended (T₂) cookie. This less amount of PA containing cookies may maintain the bioavailability of dietary minerals (Fe, Zn, and Ca) of the cookies; at the same time the lower level of PA may have some health promotional activities as an antioxidant and anti-carcinogens when ingested by humans it may reduce the risk of colon cancer and some other inflammatory bowel diseases [14].

The minimum Tannin content (9.36mg) was measured on control (T₁) cookies whereas the maximum Tannin content (66.48 mg) was measured at T₅ (20% MLP blended) cookies. Significant difference ($p < 0.05$) was observed among the treatments. The result indicated that the tannin content of formulated cookies increased with increasing level of MLP in the blend. The result clearly indicated as MLP contains more Tannin content compared with wheat flour.

3.3. Bioavailability of Minerals in Cookies

3.3.1. Iron Bioavailability

The minimum molar ratio of PA: Fe was recorded for the T₂ (5% MLP blended) cookies (0.996) and the maximum molar ratio of PA: Fe was recorded for the T₁ (control) (1.587). Significant difference ($P < 0.05$) was observed among the treatments. The results indicated (Table 1) that T₁ (control) cookies showed very less Fe bioavailability compared with others, whereas T₂ (5% MLP blended) showed the highest Fe bioavailability (0.996 < 1). The Fe bioavailability of other MLP blended cookies including control were poor, because of their molar ratio above the critical value (1) and the binding effect of Phytate (PA) on Fe may be high; whereas the Fe bioavailability of T₂ (5% MLP) might be good because of PA: Fe molar ratio (0.996) below critical value with devoid of binding effect of PA on Fe. The measured molar ratio values of PA: Fe was increased gradually when MLP amounts were increased. So the bioavailability of Fe was less when more MLP added in the blending ratio and Fe absorption in the body may be affected

by the binding property of PA. However, the formulated cookies cannot be concluded as high-Phytate foods as their molar ratio of PA: Fe was below 2 (PA: Fe > 2 means foods with high-Phytate content) [23]. The formulated cookies (PA: Fe = 0.996 – 1.587) has less molar ratio value compared with common cereal foods such as whole grain bread (the estimated molar ratio of PA: Fe = 26–64), Rye bread (whole meal) (estimated molar ratio of PA: Fe = 2 – 23) and Oatmeal (estimated molar ratio of PA: Fe = 17 – 22) according to [17]. Therefore, the bioavailability of Fe in these formulated cookies might be better than these cereal foods. Iron has a number of key functions within the body so one can get adequate amount of Fe in the food otherwise deficiency of Fe might be appeared. Deficiency of Fe (a person which has normal haemoglobin concentrations but no Fe stores in the body) ultimately leads to Fe deficiency anaemia (low haemoglobin concentration and low iron store), the most common cause of anaemia, a condition in which the blood lacks healthy red blood cells required to carry oxygen, and which results in morbidity and death because of the lack of proper function of cells in the body (26). Therefore, among the formulated cookies, T₂ (5% MLP blended) is the best source of Fe bioavailability and Fe might be easily absorbed within the gastrointestinal tract and expected to contribute to minimize Fe deficiency problems of lactating mothers as well as others by using calculated amount of cookies based on their RDA.

3.3.2. Zinc Bioavailability

The molar ratio of Phytate: Zinc of the cookies ranged from 7.583 to 11.636 as presented in Table 2. The minimum value (7.583) was recorded for T₂ (5% MLP blended) and the maximum value (11.636) was recorded for T₄ (15% MLP blended). Statistically, Significant difference ($P < 0.05$) was observed among treatments. The PA: Zn molar ratio increased as the level of MLP increased in the formulation.

According to [8] the foods with PA: Zn molar ratio greater than 15, between 5 and 15, less than 5 are considered as low (15%), moderate (35%) and high (55%) Zn bioavailability respectively. The molar ratios of all formulated cookies including control were between 5 and

15. Hence, the bioavailability of Zn in all treatments is at a moderate (35%) level. Therefore, the formulated cookies may be considered as good source of Zn for lactating mothers. The bioavailability result of Zn is similar with the work of [12] reported on cookies made from composite flour of Orange-fleshed sweet potato with wheat flour.

3.3.3. Calcium Bioavailability

The minimum and maximum PA: Ca molar ratio was recorded for T₅ (20% MLP blended) (0.014) and T₁ (control) (0.047) respectively. Statistically, significant difference ($P < 0.05$) was observed among treatments. The molar ratio of PA: Ca in all formulated cookies was below the critical value of 0.24. The decreasing of molar ratio directs to increasing the bioavailability of Ca. This result indicated that the bioavailability of Ca may not be hindered by the PA content of the formulated cookies. Because the PA: Ca molar ratio in the cookies decreased as MLP amount increase in the blend ratio. Therefore, the formulated cookies may be considered as good sources of Ca for lactating mothers and it may contributes for them to maintain bone formation, blood clotting and muscle contraction. The minimum and maximum molar ratio was recorded for T₁ (0.014) and T₅ (0.129) respectively. Significant difference ($P < 0.05$) was observed among the formulated cookies. The level of MLP increased in the blending, the molar ratio of $[Ca] * [PA] / [Zn]$ increased from 0.014 (T₁) to 0.129 (T₅) and the effect of PA on Zn appears to increase gradually. However, comparatively the $[Ca] * [PA] / [Zn]$ values of all formulated cookies were below the critical value, 0.5. This indicated that the ratio of $[Ca] * [PA] / [Zn]$ is a better predictor for Zn availability. The molar ratio less than 0.5 means there would not be interferences in the availability of Zn in the formulated cookies.

The inhibitory effect of PA on Zn absorption by forming a Calcium-Zinc-Phytate complex in the intestine makes less and soluble the Phytate complexes formed by either ion alone [26]. Therefore, Phytate has no effect on Zn bioavailability during minerals absorption in the gut; hence, the formulated cookies may be considered as good source of Zn.

Table 2. Phytate - Minerals Molar Ratio of Formulated Cookies

Treatments	PA : Fe		PA : Zn		PA : Ca		Ca * PA / Zn	
	M ± SD	CV	M±SD	CV	M ± SD	CV	M ± SD	CV
T ₁	1.587±0.001 ^a	1	7.994±0.036 ^c	15	0.047 ± 0.000 ^a	0.24	0.014 ± 0.000 ^c	0.5
T ₂	0.996±0.005 ^d	1	7.583±0.039 ^c	15	0.016 ± 0.000 ^c	0.24	0.040± 0.000 ^d	0.5
T ₃	1.256±0.005 ^c	1	10.504±0.009 ^b	15	0.017 ± 0.000 ^b	0.24	0.078 ± 0.001 ^c	0.5
T ₄	1.387±0.003 ^b	1	11.636±0.269 ^a	15	0.016 ± 0.000 ^c	0.24	0.113± 0.003 ^b	0.5
T ₅	1.252±0.003 ^c	1	10.627±0.456 ^b	15	0.014 ± 0.000 ^d	0.24	0.129 ± 0.006 ^a	0.5

T₁ = control, T₂ = 5% MLP and 95 % wheat flour, T₃ = 10 % MLP and 90 % wheat flour, T₄ = 15% MLP and 85% wheat flour, T₅ = 20% MLP and 80% wheat flour, PA = Phytate, M = Mean, CV = Critical Value, SD = Standard Deviation.

Means of the same letter (a > b > c > d > e) within a column are not significantly different ($P > 0.05$).

4. Conclusions

The bioavailability of Ca and Zn were below their critical values during increasing of MLP. But in 5%MLPblended (T_2) cookies, Fe bioavailability was in acceptable range than others due to its molar ratio (0.99) below critical value (PA: Fe <1). Therefore, T_2 (5% MLP blended) cookies have a potential to supply 53.6% of Fe to satisfy the RDA (9 mg/day) required by lactating mothers. In general, it might have a possibility to contribute better Fe content for lactating mothers to combat Iron deficiency problems.

ACKNOWLEDGEMENTS

The authors would like to thank Hawassa University, School of Nutrition, Food Science and Technology and Ethiopian Public Health Institute for their help to carry out the experiment.

REFERENCES

- [1] Abera M., Tiruneh W. and Negesse T. 2011. Effects of Feeding *Moringa stenopetalla* Leaf Meal on Nutrient Intake and Growth Performance of Rhode Island Red Chicks under Tropical Climate. *Tropical and Subtropical Agro-ecosystems*. 14 (2): 485 – 492.
- [2] AOAC. 2000. Official Method of Analysis of the Association of Analytical Chemists International, 16th edn. Washington, DC.
- [3] Erkihun Massresha. 2011. Development of Supplementary Food from Blends of Maize and Soybean Flour with Moringa Powder. MSc Thesis. Institute of Technology. Addis Ababa University. Addis Ababa, Ethiopia. 121p.
- [4] Fahey J. W. 2005. *Moringa oleifera*: A Review of the Medical Evidence for Its Nutritional, Therapeutic and Prophylactic Properties. Part 1. *Trees for Life Journal*. 1(5): p15. <http://www.TFLJournal.org/article.php/20051201124931586>. (Accessed on 30 November 2013).
- [5] USAID (United States Agency for International Development). 2012. Moringa—An Excellent Source of Nutrition. Technical Bulletin #24. 4p.
- [6] Yisehak K., Solomon M. and Tadelle M. 2011. Contribution of Moringa (*Moringa stenopetalla*, High Nutritious Vegetable Tree for Food Security in South Ethiopia: A Review. *Asian Journal of Applied Science*: 1-10.
- [7] Welch R. M. 2005. Deficiencies of Micronutrients. *Food Nutrition Bulletin* 26: 419 – 421.
- [8] WHO. 1996. Trace Elements in Human Nutrition and Health Consultation. Technical Report Series 724, World Health Organization, Geneva. 343p.
- [9] Yang R.Y. and Tsou S. C. 2006. Enhancing Iron Bioavailability of Vegetables through Proper Preparation Principles and Applications. *Journal of International Cooperation* 1(1):107- 119.
- [10] Yang R.Y., Lien C. C., Jenn C. H., Brian B. C., Manuel C. P., Chadha M. L. and Virginie L. 2006. Nutritional and Functional Properties of Moringa Leaves—From Germplasm, to Plant, to Food, to Health. Moringa and Other Highly Nutritious Plant Resources: Strategies, Standards and Markets for a Better Impact on Nutrition in Africa. Accra, Ghana. 16-18 November, 2006 workshop; 44p.
- [11] Vaintraub I. A. and Lapteva N. A. 1988. Colorimetric Determination of Phytate in Impurified Extracts of Seeds and the Products of Their Processing. *Analytical Biochemistry* 175:227 – 230.
- [12] Temesgen Laelago. 2014. Cookies Enriched with β -carotene by Blending Orange-fleshed Sweet Potato (*Ipomoea batatas* L.) and Wheat (*Triticum aestivum* L.). MSc. Thesis. Hawassa University. Food Science and Post-harvest Technology. 97p.
- [13] Price M. L., Hangerman, A. E., Butter L. G. 1978. Tannin Content of Cowpea, Chickpeas, Pigeon Peas and Mung Beans. *Journal of Agriculture Food Chemistry* 28: 459 – 461.
- [14] Phillippy B. Q., LinM. S. and Rasco B. 2004. Analysis of Phytate in Raw and Cooked Potatoes. *Journal of Food Composition Analysis* 17: 217 – 226.
- [15] Okpala L., Okoli E. and Udensi E. 2013. Physico-Chemical and Sensory Properties of Cookies Made from Blends of Germinated Pigeon Pea, Fermented Sorghum, and Cocoyam Flours. *Food Science & Nutrition* 1(1): 8–14.
- [16] Yewelsew Abebe, Alemtsehay Bogalea, Hambidgeb K. M, Stoeckerc B. J., Baileyd K, Gibsond R. S. 2007. Phytate, Zinc, Iron and Calcium Content of Selected Raw and Prepared Foods Consumed in Rural Sidama, Southern Ethiopia, and Implications for Bioavailability. *Journal of Food Composition and Analysis* 20: 161–168.
- [17] Nielsen A., Tetens I. and Meyer A. 2013. Potential of Phytase-Mediated Iron Release from Cereal-Based Foods: A Quantitative View. *Nutrients* 5: 3074 – 3098.
- [18] Norhaizan M.E. and Faizadatul A.W. 2009. Determination of Phytate, Iron, Zinc, Calcium Contents and Their Molar Ratios in Commonly Consumed Raw and Prepared Food in Malaysia. *Malaysian Journal of Nutrition* 15(2): 213 – 222.
- [19] MOH (Ministry of Health). 2006. Food and Nutrition Guidelines for Healthy Pregnant and Breastfeeding Women: A background paper. Wellington, New Zealand. 200p.
- [20] MOH (Ministry of Health). 2003. Food and Nutrition Guidelines for Healthy Adults. A Background Paper. Ministry of Health, Wellington, New Zealand. 138p.
- [21] Ma G., Li Y., Jin Y., Zhai F., Kok F. and Yang X. 2007. Phytate Intake and Molar Ratios of Phytate to Zinc, Iron and Calcium in the Diets of People in China. *European Journal of Clinical Nutrition*. 61, 368–374.
- [22] Hathan B. S. and Prassana B. L. 2011. Optimization of Fibre Rich Gluten-Free Cookie Formulation by Response Surface Methodology. *World Academy of Science, Engineering and Technology*. 60: 1077 – 1086.
- [23] Hurell R. F., Lynch S., Bothwell T., Cori H., Glahn R., Hertrampf E., Kratky Z., Miller D., Rodenstein M., Streekstra H., Teucher B., Turner E., Yeung C. K. and

- Michael B. Z. 2004. Enhancing the Absorption of Fortification Iron. A Sustain Task Force Report, Washington, DC, USA. International Journal of Vitamin and Nutrition Research. 74 (6): 387–401.
- [24] Madukwe E.U., Ezeugwu J.O and Eme, P.E. 2013. Nutrient Composition and Sensory Evaluation of Dry *Moringa oleifera* Aqueous Extract. *International Journal of Basic and Applied Sciences*. 13 (03): 100 – 102.
- [25] Kayode A. P. 2006. Diversity, Users’ Perception and Food Processing of Sorghum: Implications for Dietary Iron and Zinc Supply. Ph.D. thesis Wageningen University, Wageningen, Netherlands. pp11 – 15.
- [26] Gibson R.S., Ferguson E.L. 2008. An Interactive 24-Hour Recall for Assessing the Adequacy of Iron and Zinc Intakes in Developing Countries. International Food Policy Research Institute (IFPRI) and International Center for Tropical Agriculture (CIAT). Washington, DC.157p.
- [27] Dachana K. B., Rajiv J., Indrani D. and Prakash J. 2010. Effect of Dried Moringa (*Moringa Oleifera* Lam) Leaves on Rheological, Microstructural, Nutritional, Textural and Organoleptic Characteristics of Cookies. *Journal of Food Quality*. 33: 660–677.
- [28] Barde M.I, Hassan L.G., Faruq U.Z., Maigandi S.A. and Umar K.J. 2012. Study of Bioavailability of Ca and Zn in the Flesh of Yellow Terminaliacatappa (Linn) Fruits. *Nigerian Journal of Basic and Applied Science*, 20(3): 205 – 207.
- [29] Okaka, J.C. 2009. Handling, Storage and Processing of Plant foods. Academy Publishers Enugu, Nigeria: p132.
- [30] Chinma, C.E and D.I Gernati. 2007. Physicochemical and Sensory Properties of Cookies Produced from Cassava, Soybean and Mango Composite Flours, *Journal. Raw material Resources*, 4: 32-43.
- [31] Soetan K.O., Olaiya C. O. and Oyewole O. E. 2010. The importance of mineral elements for humans, domestic animals and plants: A review. *African Journal of Food Science*. 4(5): 200 – 222.
- [32] Jeri W. N. 2005. Osteoporosis: The Role of Micronutrients. *American Journal of Clinical Nutrition*; 81: 1232S–9S.
- [33] Imran P., Suhaib R., Faqir M.A., Tauseef M.S., Nasir M.Q. and Farhan S. 2011. Quality Evaluation of Wheat-Mungbean Flour Blends and Their Utilization in Baked Products. *Pakistan Journal of Nutrition* 10 (4): 388-392.
- [34] Joel N., Fatima K. and Stephen F. 2014. Production and Quality Assessment of Enriched Cookies from Whole Wheat and Full Fat Soya. *European Journal of Food Science and Technology*; 2(1):19- 28.