The Effects of Micronutrient Intervention on Anemia, Fitness, and Work Productivity on Female Tea Pickers

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Abstract- The prevalence of iron deficiency worldwide is 30%, in developing countries it lies between 40-45%, whereas in developed countries it is 10% (Usfar et al. 2012). Based on the research of Riskesdas 2018, it is known that the prevalence of anemia in pregnant women is 48.9% with the most age having anemia lies between 15-24 years old (84.6%). This research aims to determine the effect of micronutrient interventions on anemia, fitness, and work productivity on tea picking women in the region Pangalengan Bandung, West Java. The methode of research was experimental with 60 women of childbearing age (in Indonesia known as the so-called WUS, it stands for Wanita Usia Subur) as subjects, aged between 18-45 years old who were married and not pregnant. They were chosen purposively in the plantations Kebun Purbasari, Talun Santosa and Sedep. Subjects were divided into three groups namely: Intervention 1 (commercial micronutrients), Intervention 2 (vitamin B12-Folic Acid), and Control. This research is part of the studies funded by the Neys-van Hoogstraten Foundation (NHF). The data obtained from this research are the monitoring cards for supplement compliance, the hemoglobin status, the productivity (results of tea picking), and the physical fitness. The results showed that the level of adherence to micronutrients consumption was high, although there were still women whose adherence was lacking. Vitamin B12-Folic Acid supplement can increase the hemoglobin value. The physical fitness (VO_2 max) of the subjects before and after the intervention was relatively similar. A significant difference ($p < 0.01$) on subject productivity was identified, where the highest productivity was found in supplement vitamin B12-Folic Acid.

Index Term- anemia, fitness, micronutrient, productivity, WUS.

I. INTRODUCTION

Anemia has been known as a public health problem for many years, but the decrease in its prevalence is still very low [1]. The group that is prone to anemia is the female workers due to lack of nutrition and also due to menstruation experienced by WUS every month. These affect the hemoglobin level and productivity on those workers [2]. Based on the results of research Riskesdas 2018 it is known that the prevalence of anemia in pregnant women is 48.9% with the most age having anemia lies between 15-24 years old (84.6%) [3]. Iron deficiency anemia is a form of anemia arised following a reduced supply of iron for erythropoiesis, due to empty iron storage which ultimately leads to a degraded formation of the hemoglobin [4]. This form of anemia is often found in the world, especially in developing countries due to limited economic capacity, low consumption of animal protein, and parasitic investment which is an endemic problem [5]. Iron is needed for the formation of hemoglobin which plays a role in oxygen storage and its transportation. Some enzymes that play a role in oxidative metabolism, DNA synthesis, neurotransmitters and catabolism also require the ions iron [6].

Iron deficiency anemia almost always occurs secondary to the underlying disease, so the recovery of the underlying disease becomes an important part of the medical treatment. The treatment principles of iron deficiency anemia are first to know the causes, second to overcome them and third to provide replacement therapy by iron preparations [7]. About 80-85% of the causes of iron deficiency anemia can be identified so that the treatment can be carried out appropriately [8]. In addition to iron nutrition anemia there is also megaloblastic anemia which is an irritation caused by impaired DNA synthesis and characterized by megaloblastic cells. The cells that are first affected are those that have relatively rapid changing properties, especially the early hematopoietic cells and the gastrointestinal epithelium. The cell division occurs slowly, but cytoplasmic development is normal, so megaloblastic cells tend to become large with an increase of the ratio RNA to DNA. Preceding cells of megaloblastic erythroid tend to be destroyed in the bone marrow [9]. Thus bone marrow cellularity often increases but the production of red blood cells decreases, and this abnormal condition is referred to as an ineffective erythropoiesis. Most megaloblastic anemia is caused due to deficiency of vitamin B12 (cobalamin) and / or folic acid [10]. Based on research conducted by Indriani (2013) the highest percentage of the Hb and Ht increase on anemic WUS workers is in the iron-folate intervention of 17% and 13%, and then in the MVM (Multi Vitamin Mineral) intervention group of 15% and 12% [11] This shows that anemia is caused not only by the iron deficiency, but there are also some other things.

Organic acids such as vitamin C greatly help the absorption of non-heme iron by changing the ferric form into ferrous form [12]. This form of ferro is more easily absorbed by the body. In addition, vitamin C forms ascorbate iron groups which remain soluble at higher pH in the duodenum. Therefore it is highly recommended to eat food sources of vitamin C at every meal. In addition to vitamin C, ingredients such as citrate, malate, lactate, succinate can also facilitate iron absorption under certain conditions [13]. The intervention of folic acid and vitamin B12 will increase the hemoglobin levels so that it will improve anemia condition of the human being [14, 15].

Folic acid deficiency provides a clinical picture of megaloblastic anemia in the bone marrow and macrocytic in peripheral blood, accompanied by leucopenia. This clinical picture is based on irritation of the amino acid metabolism and inhibition of the protein synthesis. Folic acid deficiency may occur primary or secondary, namely impaired absorption in the gastrointestinal duct. Consuming folic acid in combination with vitamin B12 can improve the anemia status to become better [16].

The recommended frequency of supplement consumption for non-pregnant WUS is one per week, and during menstruation one per day. Assuming the menstruation period of a WUS worker lasts 4-8 days, thus in one month she must take 8-12 capsules / supplement pills. The consumption of micronutrients in this research is to improve the iron status for WUS workers having the marginal hemoglobin levels. In addition, this intervention treatment can hopefully improve the physical fitness and the productivity of WUS workers.

II. MATERIALS AND METHODS

This research was conducted in several tea plantations in the region Pengalengan - Bandung, West Java, covering the plantations Kebun Purbasari, Talun Santosa and Sedep. The method of this research is quasi-experimental by measuring the variables during pre-Intervention and post-Intervention. The *Intervention 1* provides micronutrients (commercial multivitamin minerals) containing ferrous gluconate (250 mg); manganese sulphate (0.2 mg); cooper sulphate (0.2 mg); folic acid (1.0 mcg); vitamin B12 (7.5 mcg); vitamin C (50 mg); and sorbitol (25 mg). The *Intervention 2* provides the intervention of vitamin B12-Folic Acid with vitamin B12 content of 0.2 mcg and folic acid of 150 mcg. This research is part of the researches funded by Neys-van Hoogstraten Foundation (NHF-Netherlands) and it has obtained the ethical approval from the Health Research Ethics Commission, Faculty of Public Health, Diponegoro University (Reference number: 22/EC/FKM/2015).

In this research, forty women of childbearing age (in Indonesian term WUS) were used as the test subjects for the intervention. They were divided into two groups called group *Intervention 1* (consisting of twenty women) and group *Intervention 2* (it consists also of twenty women). Both *Intervention* groups have the marginal hemoglobin levels (80-125 g/l). In addition to being married and having marginal hemoglobin levels, these WUS workers who fulfill the criteria for eligibility to be involved in this research are those women who are not sick, not pregnant, do not drink alcohol, do not smoke and they are willing to become participant of this research by filling out and signing the informed consent letter. The criteria for marginal hemoglobin levels used in this research are those having moderate anemia (Hb levels 80-99 g/l), light anemia (Hb levels 100-119 g/l) and those without anemia but having hemoglobin levels of the lower threshold (Hb levels 120-125 g/l). The women having the hemoglobin levels of the lower threshold still need nutrition treatment through prevention. Besides the *Intervention* groups, there was also one group called *Control* consisting of twenty women who do not suffer from anemia.

Consumption of micronutrients for *Intervention 1* is twice a week for the period of four months, whereas for *Intervention 2* the micronutrients are given every day for the same period of four months. To monitor the discipline of the subjects involved in the intervention, a card must be filled out every time they drink the micronutrients. The productivity of the subjects is determined through the quantity of the tea leaves they have picked (in kg) per week, the calculation of this productivity is supervised by the head of the plantation. The measurement of the physical fitness data is carried out using the *Queen's College Step Test* method which is a simple method as it does not require high costs, and it is easy to do. This method uses a bench of a height 16 inches (or 41.28 cm), the subject shall then jump up and down the bench for three minutes continuously with the rhythm 22 beats per minute controlled by a metronome. This test method is designed to measure cardiovascular endurance.

The obtained data is then entered into data base and further cleaned up to ensure the completeness. After completion of the cleaning up process, the data processing could then be started. The t-test analysis and ANOVA were used to identify differences of the outcome variables. Data processing and analysis used the computer program *Microsoft Excel* and *SPSS for Windows*.

III. RESULTS

The Table 1 shows the data for conformity with supplement consumption and for attendance of the subject. The level of conformity was very high, for the *Intervention 1* it lied at 94.1%, whereas for *Intervention 2* at 94.6%. The conformity level of 100% for the *Intervention 1* is achieved if the number of tablets taken is 36 tablets. For the *Intervention 2* the conformity level is counted as 100% if 122 tablets were taken. On average, the attendance of the subject per month during the intervention was 23.4 days for the *Intervention 1* and also 23.4 days for the *Intervention 2*.

Table 1. Conformity with Supplement Consumption and Attendance of the subject on work days

Variables	Intervention 1	Intervention 2
Conformity (%)		

Average±SD	94.1±13.5	94.6±6.6
Attendance (days/month) Average ±SD	23.4±2.2	23.4±2.4

The percentage of subjects determined based on the hemoglobin level (see Table 2) before and after *Intervention 1* showed a slight increase for the subjects without anemia from 0% (n = 0) (baseline) to 5% (n = 1) (endline), and for subjects with anemia the percentage has decreased from 100% (n = 20) to 95% (n = 19). The percentage before and after *Intervention 2* has increased for the subjects without anemia from 0% (n = 0) (baseline) to 35% (n = 7) (endline), and it has decreased for subjects with anemia from 100% (n = 20) to 65% (n = 13).

Table 2. The percentage of subjects (based on Hb levels) before and after Intervention

Anemia Status	**Intervention 1**				**Intervention 2**				**Control**			
	Baseline		Endline		Baseline		Endline		Baseline		Endline	
	n	%	n	%	n	%	n	%	n	%	n	%
Non-Anemia	0	0.0	1	5.0	0	0.0	7	35.0	20	100.0	20	100.0
Anemia	20	100.0	19	95.0	20	100.0	13	65.0	0	0.0	0	0.0
Total	20	100.0	20	100.0	20	100.0	20	100.0	20	100.0	20	100.0
Average Hb (g/dl)	11.2±0.6		11.6±0.6		11.1±0.8		12.0±0.5		13.1±0.7		13.2±0.7	
P[1)]	0.001				0.000				0.983			
Delta±SD	0.5±0.5[ab]				0.9±0.0[a]				0.0±1.1[b]			
P[2)]	0.003											

[1)]paired t-test [2)]ANOVA test

The results of *Intervention 1* showed an increase in Hb level from 11.2 g/dl (baseline) to 11.6 g/dl (endline), likewise also in *Intervention 2* the Hemoglobin level has increased from 11.1 g/dl to 12.0 g/dl. The t-test showed that in both intervention groups the Hb level at the endline was significantly higher than the level at the baseline. The ANOVA test results showed that there was a difference in Hb delta between *Intervention 1*, *Intervention 2,* and *Control* (p = 0.003).

The physical fitness data (VO_2 max) of the subjects are shown in Table 3. For *Intervention 1* the value VO_2 max decreased from 61.8 ± 0.8 (Baseline) to 60.5 ± 0.7 (Endline). For *Intervention 2* the value VO_2 max also decreased from 61.8 ± 0.6 (Baseline) to 60.9 ± 0.7 (Endline). The t-test results showed that VO_2 max at Baseline was higher than at Endline (p = 0.000).

Table 3. The physical fitness data (VO_2 max) of the subjects before and after Intervention

VO_2 Max	**Intervention 1**		**Intervention 2**		**Control**	
	Baseline	Endline	Baseline	Endline	Baseline	Endline
Mean±SD	61.8±0.8	60.5±0.7	61.8±0.6	60.9±0.7	62.5±0.3	61.6±0.6
p[1)]	**0.000**		**0.000**		**0.000**	

[1)]paired t-test

The Table 4 shows the distribution of subjects according to productivity before and after the intervention for both groups *Intervention* and group *Control*. The average value of the productivity before and after the intervention for group *Control* was 62.6 ± 16.8 kg of tea / day and 66.6 ± 17.7 kg of tea / day. The results of the group *Intervention 1* showed an increase in productivity from 69.6 kg of tea / day (baseline) to 74.1 kg of tea / day (endline). Similarly, the *Intervention 2* experienced an increase in productivity from 72.4 kg of tea / day to 85.6 kg of tea / day. The t-test showed that the productivity at the endline was greater than at the baseline (p = 0,000). The ANOVA test results showed that *Intervention 2* increased the productivity higher than *Intervention 1* and *Control* (p = 0.000).

Table 4. Subject productivity (kg/day) before and after Intervention

Productivity	**Intervention 1**		**Intervention 2**		***Control***	
	Baseline	Endline	Baseline	Endline	Baseline	Endline
Average±SD	69.6±22.9	74.1±23.0	72.4±18.8	85.6±18.1	62.6±16.8	66.6±17.7
p[1)]	**0.000**		**0.000**		**0.002**	
Delta	4.5±4.7[a]		13.2±5.8[b]		4.0±5.0[a]	
p[2)]			**0.000**			

1)paired t-test 2)ANOVA test

IV. DISCUSSION

One of the factors influencing the success of supplementation is the conformity in consuming the supplements. If the level of conformity is high, the effect will then be more meaningful. The level of conformity in consuming the supplements for both groups *Intervention* is relatively high, although there are still some subjects whose conformity is lacking. The reason for the lack of conformity is forgetfullness, not feeling well, and so on. Aside from level of conformity, the attendance is also very important, and this is influenced by his health. Subjects who are sick or unwell will potentially be absent from work for health reasons. The absence can also be influenced by other things such as death, marriage, circumcision and other social events.

The results of this research showed consistency with those researches conducted by Daasgupta *et al.* (2016). It showed that anemia suffered by WUS will affect their health so that in turn will effect their productivity and their attendance which is lower compared to WUS having no anemia [17]. Therefore it is necessary to increase the food consumption patterns to being rich in Fe which later on will help improve its iron status, according to Ghose *et al*. (2016), the more consumption of the iron intake, the more improved the iron status of WUS having anemia will be [18]. Indriani *et al*. (2013) found that the anemia level of WUS workers was quite high, so iron supplement was needed to improve their iron status [19]. Consumption of ferrous supplements is a must for WUS workers, because they are not able to increase their Hemoglobin level if they only rely on food.

This research showed an improvement on the Hemoglobin levels in each *Intervention* group, through the combined consumption of iron and multivitaminmineral, and through the consumption of the B12 folate as well, thus in line with Muwakhidah's research in 2009 which showed an increase oft he Hemoglobin levels. Referring to the research carried out by Mulyawati that the Hemoglobin level is increased after consumption oft he iron supplements, this phenomenon of increased Hemoglobin level has also been found in the group for that the B12 and folic acid was given. Consuming the supplement interventions will increase the metabolism, subsequently the cell function will become better and be more optimal which in turn leads to a better food absorption, thus it will increase the appetite, and consequently it can increase the body weight. The results of Sahana *et al.* (2015) showed that consumption of iron folate can increase the Hemoglobin levels, Body Mass Index, work productivity and concentration [20]. The results of this research are consistent with those made by Ahmed in Bangladesh, namely consuming iron, folic acid and vitamins will increase the Hemoglobin level by 1.22 g/dL. This result is in line with other studies that showed the Hemoglobin levels of 3.28 g/dL after consumption of iron and B12. This is consistent with the theory that consuming the iron supplement will improve the process oxygenation in the cells, increase metabolism, and the cell function will be optimal, thus at the end the food absorption becomes better [21].

The results of this research are in line with the study performed by Makurat *et al*. (2014) which showed a positive effect between iron consumption and Hemoglobin levels on the working women and have a strong correlation [22]. In addition, it is proven that the lower the iron consumption, the lower the Hemoglobin level, so that there are still many working women suffering from anemia due to little consumption of the iron. This is consistent with the study made by Maesaroh (2007) which showed that 81.2% of women have low level of iron consumption and low level of hemoglobin as well, they are suffering from anemia that confirms a significant influence between iron consumption and the appearance of anemia [23]. The research of Anggraeni (2014) found the outcomes that there was a positive relationship between iron consumption and the appearance of anemia on the women living in the region Kendal [24]. Similarly, according to Coad and Pedley, the main factor causing anemia is lack of iron consumption, with approximately two-thirds of the body's iron are present in the red blood cells hemoglobin [25]. According to Gibson (2005) iron consumption plays an important role in the formation of hemoglobin [26]. If the hemoglobin level is low, it can reduce the work productivity and decrease the physical stamina that later on can make the body more prone against infection.

This research demonstrated the *Intervention 2* as the most influencing treatment, it has happened because the folic acid is needed for the formation of the red blood cells in the bone marrow, whereas the B12 is needed to convert the folate into an active form and in anormal functioning of the metabolism of all cells especially the cells of the digestive ducts, bone marrow and neural networks (almatsier). More influences on the B12 folate intervention had been identified compared to iron intervention, possibly due to the anemia driven by deficiency on vitamin B12 and folic acid (B9). The significant relationship between vitamin B12 consumption and Hemoglobin level identified in this research is in line with the role of the vitamin B12 to function in the Hemoglobin synthesis and red blood cells through metabolism of fat, protein, and folic acid. The Vitamin B12 also acts as a cofactor in the formation of energy from protein and fat through the succinyl_CoA formation that is needed in Hemoglobin synthesis. The results of another study conducted by Indriani (2011) showed that the iron folate supplement in WUS workers having marginal Hemoglobin level could significantly increase Hemoglobin level by 8%, whereas the multivitamin minerals could indeed increase the hemoglobin level by 6% [27].

The results of Oppusunggu`s research (2009) stated that iron consumption for the duration of three months successfully increased the hemoglobin level by 2.14 g/dL and it is followed by an increase in work productivity by 16.28%, the relationship between increased hemoglobin levels and work productivity showed a significant result ($p < 0.05$) [28]. Another study conducted by Permaesih *et al*. (2011) showed that the combined supplement of micronutrients and iron can increase the hemoglobin level even higher compared to groups that only obtain the iron supplement alone, additionally the combined supplementation of vitamins and iron can give a positive effect on changes in transferrin levels as an indicator of iron status [29]. Changes in hemoglobin levels are not only influenced by multivitamin supplement, they are also influenced by other supplements which play a role in the formation of hemoglobin and inhibitors.

Based on the physical fitness test results, the workers who are the subject of this research are used to walk daily, even on inclined paths and they are not doing light activities such as carrying the load of the picked tea leaves. It can be seen from the Table 4 that the results of the physical fitness test before and after the intervention are relative the same. Although the factor activity does affect the fitness, in this research the daily activity patterns are assumed to be relatively similar between the subject groups because their daily tasks are the same, particularly when they are working in the plantations. This is in line with other studies that demonstrated the benefits of iron supplement on physical activity (VO_2 max) of the childbearing age women [30, 31]. In these studies the level of physical fitness of the subject has also been evaluated through a method bench jump up and down.

The physical fitness tests are strongly influenced by the ability and endurance of the muscles. According to Whitney and Rofles (2008), the training for muscle strength and endurance will strengthen the muscles so that the body will not get tired quickly [32]. The muscle strength belong to the basic components of the body fitness as they are used to carry out daily activities. The more exercises are made for muscle strength and endurance, the more trained the muscles will be. The factors physical activity, intensity, duration and exercises categorized as routine can increase the adaptation (in term of endurance and strength) of human being to various types of activities or exercises. This will allow the human being to do optimally activities and trainings in a relatively longer period of time until they feel tired. The standard used to determine the VO_2 max value of the subjects having anemia is reduced by 20% from the VO_2 max of normal people without anemia [33]. Research conducted by Neto *et al*. (2011) showed that adolescents having light activity level and owning a low VO_2 max value would be more at risk to become exposed to the metabolic syndrome [34]. Therefore, preventive action is needed by increasing the sport activities routinely. The results of the conducted research showed arelationship between micronutrient consumption and fitness, such if an appropriate micronutrient were given to someone, he/she will be more fit and healthy [35].

The tea picking productivity is measured from the number of tea leaves that are picked every day. The table 4 shows that the productivity is increased in the groups *Control* and *Interventions* (of Iron and Vitamin B12 folate). Statistical method showed a significant difference ($p < 0.01$) between productivity and intervention, where the intervention of vitamin B12 folate is identified as the most influencing one. Chan *et al.* (2016) presented the results of his research that the consumption orally of the vitamin B12 would reduce the symptoms of anemia because it boosts the metabolism in the body and it also plays a vital role in the red blood cell formation [36]. This folic acid is an important element in DNA synthesis in collaboration with vitamin B12 [37]. In addition, folate is also involved in the red blood cell formation. This is proven through research conducted by Haidar *et al.* (2010): If folate is deficient then the body may not be able to produce enough red blood cells [38]. The produced red blood cells are abnormally large in size and they have a shorter endurance compared to normal ones.

V. CONCLUSION

One of the factors influencing the success of supplement is the conformity in consumimg the supplements. With a high level of conformity, the effect will be more meaningful. The conformity level of consumption in both groups *Interventions* is classified as high, apart from the conformity, the attendance is also very important, and this is influenced by his health. In group *Intervention 2* namely B12 and folic acid the hemoglobin level has increased compared to group *Intervention 1*. The physical fitness data VO_2 max of subjects from both *Interventions* were relatively similar. The productivity value for both *Interventions* has increased from 69.6 to 74.1; 72.4 to 85.6, so there is a significant difference ($p < 0.01$) between the productivity and kind of treatment, where the *Intervention 2* is found as the most influencing treatment.

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