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**THE RELATIONSHIP BETWEEN pH VALUE OF IRON SUPPLEMENT WITH
 THE ABSORPTION OF IRON IONS IN DECIDUOUS TEETH (AN IN VITRO
 STUDY)**

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ABSTRACT

Background: Iron deficiency anemia is a prior health issue that often occurs in school-aged children. Iron substances have a critical role in neurological growth, so it is necessary to give iron supplements as therapy. Iron supplements can affect deciduous teeth. **Aims:** To measure the pH and absorption value of iron supplements in deciduous teeth and determine the relationship between pH value of iron supplements with the absorption of iron ions in deciduous teeth. **Material and Methods:** This study is an experimental in vitro- study. Sample groups used iron supplements (Ferriz, Sangobion Kids, Ferro-K). The assessment of pH value used pH meter, and iron ions absorption used Atomic Absorption Spectrometry. Spearman's Rank correlation test was used to analyze the correlation between iron supplements pH value and iron ions absorption in deciduous teeth. **Results:** The result showed that All iron supplements have acidic content, Sangobion Kids was a lower pH value, and Ferriz had a higher pH value. For the absorption iron ions value, the lowest was Sangobion Kids(0,5454), and the highest was Ferro-K (0,7979). **Conclusion:** pH value of iron supplements have a significant relationship with the absorption of iron ions in deciduous teeth and each pH value for Ferriz; Sangobion Kids; and Ferro-K are 6,0; 4,3; and 4,5 and the value of iron ions absorption in deciduous teeth are 0,5838; 0,5454; and 0,7979.

Keywords: Iron Ions Absorption, Iron Supplement, pH Value,

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INTRODUCTION

Iron deficiency anemia is a major health problem that occurs worldwide, both in developing and developed countries. Iron deficiency anemia is caused by a decrease in hemoglobin levels in erythrocytes according to age with WHO criteria, an average Hb concentration of <31%, serum Fe levels of <5µg/dl, and transferrin saturation of <15%. This is the most common nutritional deficiency problem in the world, especially in developing countries, and is one of the most common types of anemia in school-age children. The most common causes seen in children with iron deficiency anemia are inadequate nutritional intake along with rapid child growth, low birth weight, and gastrointestinal disorders due to excessive cow's milk consumption. Iron deficiency anemia in school-age children is a serious health problem in Indonesia because its prevalence is more than the national standard, which is ≥20%. This is marked by the prevalence of anemia that occurs in children aged 5-12 years reaching 29% based on the Basic Health Research data in 2014.¹⁻⁴

Iron plays an important role in neurological development in children. Iron is needed for the process of myelination of neurons, neurogenesis, and differentiation of brain cells that affect the sensory system, learning, remembering, and behavior and also as a cofactor enzyme that synthesizes neurotransmitters.⁵ A program to provide free iron supplements was formed by all countries in the world for low-income people.⁴ Iron supplements in liquid form often use acid to maintain chemical stability, control tonicity, and physiological compatibility.⁴ According to research by Alexandria, et al. (2015) the low pH value of the drug drop stored at room temperature can cause degradation on the tooth surface, thus increasing the roughness of the tooth surface.⁶ Through a review of several in-vitro studies, the acid content in iron supplements resembles tooth etching so that iron absorption increases and tooth discoloration can occur.⁷

According to research by Pasdar, et al. (2015) the use of iron supplements can cause erosion due to a decrease in the average microhardness value on deciduous tooth enamel.⁸ As claimed by Alves, et al. (2011) in research with the pH- cycling model, iron does not support remineralization so that along with the results of in-vitro research conducted by Rathi, et al. (2017) a remineralizing agent such as nanohydroxyapatite is needed on the enamel surface after giving iron supplements for five minutes twice a day which is repeated until the seventh

day.⁹⁻¹⁰

In research conducted by Gauw, et al. (2017) it is known that iron can have a protective effect against the demineralization process and according to research by Lavaee, et al. (2017) iron can inhibit the development of *Streptococcus mutans* bacteria.^{11,12}

Based on the differences in the results of previous studies regarding the use of iron on teeth, the researcher wanted to know the relationship between the pH value in iron supplements with the absorption of iron ions on deciduous teeth.

METHODS

In the in-vitro study conducted, 24 subjects were selected, which were upper central incisor deciduous teeth without caries or enamel lesions, without erosion, without crown fractures. The subjects were then divided into 8 subjects for each treatment group. There were 3 groups that use iron supplements with different brands, namely group 1 using the *Ferriz, Nicholas Laboratories* brand, group 2 using the *Sangobion Kids, Merck Consumer Health Prod*, and group 3 using the *Ferro-K, Novell Pharmaceutical lab* brand.

The deciduous tooth samples were cut at the CEJ using a *diamond separating disc* coated with 3 layers of nail polish in the pulp chamber. The deciduous teeth were soaked in artificial saliva for 24 hours in an incubator at a temperature of 37°C. The pH of various iron supplements was measured using a pH meter, repeated three times for each group were immersed in 5 mL of iron supplement solution for 72 minutes (based on the recommendation of the Indonesian Pediatrician Association, the duration of iron supplementation is twice a week for 3 consecutive months each year. The estimated iron supplement solution in the oral cavity is 3 minutes, so the total duration of iron supplement in the oral cavity is known to be 72 minutes). The specimens were then brought into a mixture of 5 mL iron supplement solution and 5.5 mL distilled water and then washed with 10 mL distilled water. The samples were immersed in a 2M HCL solution for 24 hours. The tooth samples were lifted and the absorption level was measured using *Atomic Absorption Spectrometry (Perkin Elmer, USA)* with a wavelength of 248.3 nanometers and a resolution of 0.062 ppm.

Data analysis began with a normality test using Shapiro-Wilk, then a correlation test between pH values and iron ion absorption values in deciduous teeth can be performed using Pearson's correlation test for normally distributed data or Spearman's Rank for non- normally distributed data.

RESULTS

Based on the research data description regarding the pH value of iron supplements and the absorption value of iron ions in deciduous teeth from three sample groups, the values are known as follows:

Table 1. The pH value of iron supplements

Iron supplement Drops	Trial	Mean ± SD
<i>Ferriz</i>	3	6,000 ± 0,1000
<i>Sangobion Kids</i>	3	4,333 ± 0,577
<i>Ferro-K</i>	3	4,567 ± 0,577

In Table 1 it is known that all tested iron supplement drops are acidic with the lowest pH value being *Sangobion Kids* iron supplement and the highest pH value is *Ferriz*. So, it can be known that *Sangobion Kids* are more acidic compared to other sample groups tested.

Tabel 2. The absorption of iron ions in deciduous teeth

Iron Supplement Drops	Trial	Mean	± SD
<i>Ferriz</i>	8	0,5838	± 0,46030
<i>Sangobion Kids</i>	8	0,5454	± 0,17485
<i>Ferro-K</i>	8	0,7979	± 0,48441

In Table 2, it is known that all iron supplement drops can cause iron ion absorption in deciduous teeth, with the lowest iron ion absorption in the *Sangobion Kids* iron supplement group, while the highest is in the *Ferro-K* iron supplement group. Therefore, it is known that iron ions absorbed by the deciduous teeth in the *Sangobion Kids* sample group are fewer. Whereas in the *Ferro-K* drop the iron ions absorbed by the deciduous teeth are greater compared with the other sample groups tested.

Based on the statistical test, the data distribution shows that the data is not normally distributed ($p < 0.05$),

so the analysis was continued with the *Spearman's Rank* correlation test. The correlation analysis between the pH value in iron supplements and the absorption of iron ions in deciduous teeth shows the following results:

Table 3. The Relationship Between The pH Value of Iron Supplements and Iron Ion Absorption

	Correlation Coefficient	P Value
pH Value	-0,765	0.016
Iron Ion Absorption Value		

Based on Table 3 above, it is known that the correlation coefficient value is -0.765 with a significance level (p) of 0.016 which is smaller than 0.05 ($p < 0.05$). Therefore, it can be concluded that there is a significant relationship between the pH value of iron supplements and the absorption of iron ions in deciduous teeth, with an inversely proportional relationship between the two.

DISCUSSION

Based on the measurement results of the pH value in iron supplement drops (Table 1), it is known that all iron supplement drops are acidic. The acidity level of a substance is known based on the pH value.¹⁸ The pH value in *Sangobion Kids* drops is lower than other sample drops (4.333). This is due to the addition of citric acid in *Sangobion Kids* drops, while in *Ferriz* and *Ferro-K* iron supplement drops, there is no such content.

Nutrition and vitamin supplement drops require a preservative agent such as potassium sorbate, sodium benzoate, and citric acid to prevent decomposition due to microbial growth or chemical changes.¹⁹⁻²¹ Additional compositions in *Sangobion Kids* such as vitamin B1 (Thiamine), B2 (Riboflavin), B6 (Pyridoxine), B3 (Nicotinamide), B7 (Biotin) allow for the use of additional preservative agents compared to *Ferriz* and *Ferro-K* iron supplement drops. *Ferriz* and *Ferro-K* iron supplement drops only use potassium sorbate as a preservative agent, while *Sangobion Kids* drops use citric acid, potassium sorbate, and sodium benzoate. The addition of citric acid can increase the effectiveness of sodium benzoate and potassium sorbate due to its acidity.²² Meanwhile, the pH value in *Ferriz* drops shows a higher value compared to *Sangobion Kids* and *Ferro-K* drops (6.000). This can be caused because *Ferriz* drops use potassium sorbate which has optimum ability at pH 5-6.²³

The results (Table 2) show that all iron supplement drops can cause iron ion absorption in deciduous teeth. *Sangobion Kids* drops have a lower iron ion absorption value compared to *Ferriz* and *Ferro-K* drops (0.5454). The limited iron ion penetration to the surface of the deciduous teeth has been shown by the low absorption value in the *Sangobion Kids* drops. The lowered pH of *Sangobion Kids* (4.333) seems not consistent with the mechanism of acid penetration that occurs when the pH in the oral cavity decreases. A decreasing pH value may increase the surface porosity of enamel and the diffusion process that can make inorganic elements from external solutions (iron supplements) may be transferred to the enamel surface. The result deviates from the reported results.^{17,18,19} The absorption value of iron ions is influenced by the content level contained in it. In *Sangobion Kids* supplement drops, there are additional compositions that are not present in the two iron supplement drops used in this research (*Ferriz*, *Ferro-K*) such as the presence of Vitamin B1 (Thiamine), B2 (Riboflavin), B6 (Pyridoxine), B3 (Nicotinamide), B7 (Biotin) which can interfere with the assessment of iron ion absorption. This is because there are many content levels contained in *Sangobion Kids* drops so that there are more molecules that absorb light at the wavelength used.

Based on this research, a significant correlation was also obtained between the pH value and iron ion absorption in deciduous teeth, showing an inversely proportional relationship between the two. This inversely proportional nature indicates that the lower the pH value in iron supplement drops, the more iron ions are absorbed in deciduous teeth. Results of this research contrast with those of the study performed by Hekmatfar, et al. (2018) which states that there is no significant relationship between pH and iron ion absorption in deciduous teeth. This is suspected due to differences in drop doses, tooth immersion volume in iron supplements, contact time, contact surface area.⁴

The dose of iron supplement drops used in this study is the same, namely 15 mg of Fe elemental for every 5 mL with a similar type of component, namely *the iron polymaltose complex*, which is known to potentially cause staining on teeth.¹⁹ The use of different Fe elemental doses for each group in the Hekmatfar, et al. (2018) study can affect the concentration in the tested iron supplement drops because the concentration is proportional to the substance mass.^{4,26} In addition to the substance mass, the concentration is influenced by the solution volume. The solution volume in this study is 5 mL based on the recommended use of iron supplements on the product packaging used, namely for one-time consumption equivalent to one measuring spoon as much as 5 mL. The condition of the teeth where the entire surface is submerged is also considered as a condition when the solution is in the oral cavity. Based on Lambert Beer's law, concentration can affect the level of absorption of a substance.²⁷

In this study, the contact time of iron supplements on teeth is 72 minutes. A longer contact time compared to the research conducted by Hekmatfar, et al. (2018) affects the level of iron ion absorption in deciduous teeth. This is in line with the research conducted by Tayebi, et al. (2019) which shows that a long

tooth contact time with iron (about 24 and 48 hours) can cause color changes in teeth.^{4,28}

In addition to the factors of drop dose, tooth immersion volume in iron supplements, and contact time that are suspected to affect iron ion absorption, a larger contact surface in this study allows more substances to be absorbed by the tooth surface. In this study, all teeth come into contact with iron supplements, assuming that the entire tooth surface comes into contact with iron supplements when consumed. In similar research, Hekmatfar, et al. (2018) only used the buccal surface of the anterior teeth with a size of 0.4 cm × 0.4 cm in contact with iron supplements.⁴

CONCLUSION

Based on the research results, it is known that there is a significant relationship between the pH value in *Ferriz*, *Sangobion Kids*, and *Ferro-K* iron supplements and iron ion absorption in deciduous teeth. The pH values in *Ferriz*, *Sangobion Kids*, and *Ferro-K* iron supplements are 6.0; 4.3; and 4.5, respectively. The iron ion absorption values in deciduous teeth with the use of *Ferriz*, *Sangobion Kids*, and *Ferro-K* iron supplement drops are 0.5838; 0.5454; and 0.7979, respectively. Further research with other methods needs to be done to determine the impact of iron ion absorption on teeth, such as the emergence of black stains on teeth. The administration of remineralization agents or supplements containing calcium and phosphate can be done as a preventive measure against the demineralization process due to the use of iron supplements.

Conflict of Interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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