Exploring the Therapeutic Potential of Date (*Phoenix dactylifera*) Bars in Anemic School-Going Children

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ABSTRACT

Background: Iron deficiency anemia (IDA) is a common nutritional disorder among children and may negatively influence growth, cognitive development, and overall health. Food-based interventions using locally available nutrient-rich ingredients may provide complementary approaches for improving iron status. Dates (*Phoenix dactylifera L.*) contain minerals, dietary fiber, and bioactive compounds that may contribute to improved nutritional quality.

Objective: This study aimed to develop date pulp-based functional bars, assess their sensory acceptability, and evaluate their potential effects on anemia-related hematological parameters among school-going children with IDA.

Methods: A longitudinal intervention study was conducted among 60 anemic school-going children aged 8–14 years at Aghosh Grammar Higher Secondary School, Lahore, Pakistan. Participants were assigned into three groups (n=20/group): control (T0; 0% date pulp), 50% date pulp (T1), and 60% date pulp (T2). Functional bars were prepared using date pulp, oat flour, sunflower seeds, crushed coconut, and other ingredients. Participants consumed one 30 g bar daily during the school lunch period for 60 days. Sensory characteristics were evaluated using a 9-point hedonic scale, while hemoglobin, hematocrit, serum ferritin, and anthropometric parameters were assessed before and after intervention.

Results: The 60 % date pulp formulation (T2) had the best sensory acceptability. After 60 days, hemoglobin levels increased from 11.14 ± 0.5 to 12.80 ± 0.6 g/dL in T2, compared with 11.00 ± 0.6 to 12.30 ± 0.6 g/dL in T1 and 10.80 ± 0.5 to 11.06 ± 0.5 g/dL in T0. The same was found in hematocrit and serum ferritin which showed greater change in date pulp groups than control ($p < 0.05$).

Conclusion: Date pulp based functional bars can be beneficial for the improvement of anemia-related biomarkers among school going children, especially in 60% formulation. Date bars could be a useful food supplement in a school nutrition program, because of their nutritional benefits and palatability. More research with larger populations, longer follow-up and detailed biochemical testing is suggested.

Keywords: Date bars, functional food, hemoglobin, hematocrit, ferritin, iron deficiency anemia, Phoenix dactylifera.

INTRODUCTION

Anemia is a widespread nutritional disorder, a major nutrition public health problem, especially in children and adolescents in developing countries. It is defined as a decrease in the amount of hemoglobin in blood or the number of red blood cells, which is associated with a decreased capacity for transport of oxygen in blood.[1] Iron deficiency anemia (IDA) is the most prevalent type of anemia and a significant factor in poor growth, cognitive function, fatigue and physical stamina of school-age children.[2] The World Health Organization (WHO) has included childhood anemia in its list of nutritional concerns, and inadequate dietary iron intake, poor iron absorption, infections and/or increased nutritional needs during growth are all important contributing factors to childhood anemia. [3] Iron-deficiency in school-age children is especially problematic due to their fast rate of growth, higher metabolic demands, need for iron, and increased requirements for iron.[4] Iron is essential for oxygen transport, brain development, making neurotransmitters, and energy metabolism.[5] Children who suffer from iron deficiency for extended periods of time can have adverse effects on their cognitive function, learning capacity, immunity and academic performance.[6] Despite the provision of iron supplementation and fortification programmes for the control of anaemia, the obstacles to efficacy include lack of compliance, gastrointestinal side effects, limited access and over-reliance on pharmaceutical solutions, which makes it a challenge to find sustainable food-based solutions.[7]

Biofortified foods, with functionalities added with nutrients and bioactive compounds, have been considered as possible alternatives for preventing and alleviating the nutritional deficiencies. *Phoenix dactylifera L.* (date fruit) is a nutrient-rich traditional food product that is widely consumed in many parts of the world, and has been noted for its health-promoting properties.[8] The nutritional and therapeutic properties of dates are attributed to their high content of carbohydrates, dietary fiber, minerals, vitamins, phenolic compounds and antioxidants.[9] The fruit is rich in minerals such as iron, potassium, magnesium, calcium and zinc which play a key role in normal physiological functions and in hematological health.[10] Dates have a moderate amount of iron relative to iron supplements, but regular dates

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consumption can help to increase dietary iron intake.[11] Furthermore, vitamin C and bioactive phytochemicals could improve mineral absorption and/or help to reduce oxidative stress due to nutritional deficiency. The dates contain phenolic compounds, flavonoids, and carotenoids, which are known for their antioxidant and anti-inflammatory properties, indicating their potential benefits in promoting overall health and reducing oxidative damage.[12]The antioxidant, antimicrobial and protective properties of date fruits have been shown by previous research[13,14] which indicates that they could have beneficial effect when used as an ingredient in a functional food.

Food products labeled with dates can be an effective tool to increase the acceptance and access for children. Convenience, energy-rich and readily available, date bars are an excellent source of nutrition for use in school-based nutrition programs as a dietary supplement. These products are often made using dates in conjunction with other nutrient-rich components, which can help to create a more beneficial nutritional profile, and may also offer a kid-friendly way to access essential nutrients. The products can be made with dates and other nutrient-rich ingredients, providing added nutritional value as well as a child-friendly alternative to traditional supplement offerings. These interventions can be especially useful in areas with high levels of anemia and poor nutrition status, as well as low consumption of fortified foods and medical supplements.

Despite extensive evidence [2, 9, 15] regarding the nutritional composition and health benefits of dates, limited research has investigated their therapeutic effects on anemia, particularly among school-going children. Dietary interventions using locally available, culturally acceptable, and nutrient-rich foods may complement existing anemia-control programs and improve long-term adherence. Evaluating the impact of date-based products on hematological parameters, including hemoglobin concentration and iron status, may provide valuable evidence for their role in childhood anemia management. Therefore, exploring the therapeutic potential of date (Phoenix dactylifera) bars in anemic school-going children represents an important step toward developing affordable, sustainable, and functional dietary interventions. The present study aims to assess whether regular consumption of date bars can improve hematological outcomes and contribute to reducing anemia-related nutritional challenges among children.

METHODOLOGY

Study Design, Ethical Approval, and Participants

A longitudinal intervention study was conducted to evaluate the effect of date (*Phoenix dactylifera L.*) bars on hematological parameters among school-going children with iron deficiency anemia. The study was carried out at Aghosh Grammar Higher Secondary School, Lahore, Pakistan, from January 2024 to January 2025. The research protocol was approved by the Institutional Review Board (IRB) Committee of Minhaj University Lahore, Pakistan (Ref: MUL/CRD/23/65 dated 12-10-2023). The study was conducted according to the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from parents/guardians before enrollment, and assent was obtained from participating children after explaining the study objectives and procedures.

Study Population and Sample Size Determination

The study included 60 school-going children (30 boys and 30 girls) aged 8–14 years diagnosed with iron deficiency anemia. Participants were recruited using purposive sampling from the selected school population based on predefined eligibility criteria. Sample size was estimated using power analysis for a one-way ANOVA design, considering hemoglobin concentration as the primary outcome. Sample size calculation formula (ANOVA) as follows:

n=((k-1) (Z_α+Z_β) ^2)/f^2 +1

Where:

n = sample size per group

k = number of groups (3 intervention groups)

Zα = 1.96 (for α = 0.05, two-tailed)

Zβ = 0.84 (for 80% power)

f = effect size (Cohen's f)

Assuming a significance level of α = 0.05, 80% statistical power, three intervention groups, and a moderate expected effect size (Cohen's f = 0.25), the calculated sample size was approximately 20 participants per group. Considering possible attrition, a total of 60 children (20 per group) were recruited for the study.

Eligibility Criteria

The children included in the study were aged between 8 and 14 years, which were diagnosed as iron deficiency anemia. Anemia was confirmed by the World Health Organization (WHO) criteria, which is hemoglobin concentration less than 12g/dL for children aged 8–14 years. Patients who had a chronic disease, an acute infection, inflammatory condition, were allergic or intolerant to the study components, or were taking iron supplements, multivitamins or other nutrient intervention for anemia were excluded. To assess iron storage status, serum ferritin levels were measured, and to assess hematological improvement, hemoglobin and hematocrit values were measured.

Data Preparation and Collection Procedure

Dates were bought from local market of Lahore, Pakistan. Processed fruits were hand inspected, washed, deseeded and converted into smooth pulp in hygienic conditions using a food processor. The three functional bars were formulated as T0 (control), T1 (50% date pulp) and T2 (60% date pulp). Control formulation was formulated without date pulp while treatment formulations used various concentrations of date pulp. Oat flour, sunflower seeds, crushed coconut and honey were added to enhance texture, flavor and acceptability of the bars. The ingredients were processed for about 5-10 minutes until a uniform mixture was achieved. The mixture was spread on parchment paper for food use and compressed into even bars, which were then left to stabilize for an hour. The weight of each bar was around 30 g, and each bar was separately packed in airtight food-grade packaging. Bars prepared were stored at 4-8°C before they were distributed. The nutritional composition of developed date bars was estimated on the basis of the contribution of the different ingredients used in the formulations. Commercial dates of Pakistan were found to be the main functional ingredient as it contains high amount of carbohydrate, dietary fiber, mineral profile. The subjects were divided equally into three groups (n=20 per group):

- T0 (Control group): Control bars with no date pulp.
- T1 (Treatment group): Bars with 50% date pulp were administered.
- T2 (Treatment group): Bars with 60% date pulp.

During the school lunch time, each subject was given one 30 g bar per day for 60 consecutive days. Consumption was monitored by teachers and research staff. Records were kept every day for compliance and adverse effects as well as missed servings. A trained panel consisted of judges to assess sensory acceptability of functional bars. These parameters were evaluated: colour, flavour, taste, texture, sweetness, appearance and overall acceptability. The scale used was 9-point hedonic scale, from extremely disliked (1) to extremely liked (9). Anthropometric measurements were taken at the start of the study and at the end of the 60-day study. Body weight and height were measured by

standard procedures and body mass index (BMI) was computed as weight/height2.

BMI= Weight(kg) / (Height(m)^2)

Pre and post blood samples were taken to assess hematological changes. Hemoglobin (Hb) level, hematocrit (HCT) level and serum ferritin levels were measured.

Hemoglobin concentration was measured using an automated hematology analyzer and expressed as g/dL. Hematocrit was determined using automated hematological analysis and expressed as percentage (%). Serum ferritin was measured using an enzyme-linked immunosorbent assay (ELISA) and expressed as ng/mL. Hemoglobin: ≥12 g/dL (8–14 years); Hematocrit: 36–40% and Serum ferritin: 7–140 ng/mL were used for interpretation. In-laboratory quality-control was used throughout the analysis.

Statistical Analysis

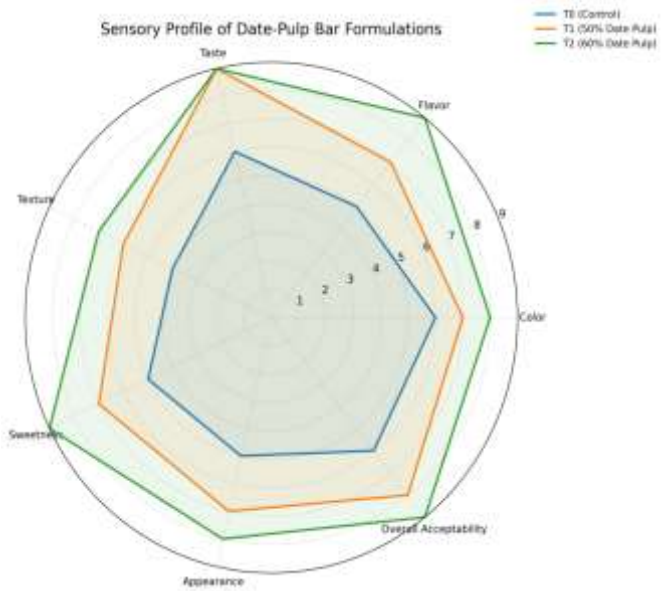
Statistical analysis was performed using IBM SPSS Statistics version 23. All data were analyzed and presented as means ± SDs: Paired sample t-test was used to compare baseline and post-intervention values within each group. One-way ANOVA was used to compare differences among treatment groups. Statistical significance was considered at $p<0.05$. Results were presented in tables and figures showing baseline and post-intervention values for each treatment group.

RESULTS

Sensory Evaluation of Functional Bars

The statistical results showed a significant decreasing trend from T0 to T2, as shown in the web diagram (Fig. 1). The color scores for the dates pulp bar significantly ($P < 0.05$) improved from T0 (6.0 ± 0.5) to T2 (8.0 ± 0.5). Similarly, the mean scores for sensory flavor showed a significant increase from T0 to T2, and their values were 5.0 ± 0.4 and 9.0 ± 0.4, respectively. As for taste, the highest score was observed in T2 as compared to T1 and T0. The mean texture scores also showed significant ($P < 0.05$) differences between T0 (4.0 ± 0.5), T1 (6.0 ± 0.6), and T2 (7.0 ± 0.5). The mean overall acceptability values for all the treatments followed a significant increasing trend ($P < 0.05$) from T0 (6.0 ± 0.5) to T1 (8.0 ± 0.6) and to T2 (9.0 ± 0.5). The results of all the sensory attributes showed that functional bars are an overall acceptable food product according to the trained panel of judges.

Figure 1. Radar/web representation for Sensory parameters of functional bars



The sensory aspects of the bars were significantly ($P < 0.05$) affected after the addition of dates pulp in the bars at various levels (50 & 60 %) in comparison with the control (bars with 0% date pulp).

ANTHROPOMETRIC MEASUREMENTS:

Effect of Date Bars on Body Mass Index (kg/m2) of Anemic Children

The data presented in Table 1 depicted that the BMI (kg/m2) within all groups increased slightly during the intervention, with the increase seen with the intervention groups (T1 and T2) being correlated with the control group (T0) with a moderate to high correlation. The control group (T0) improved from 16.58 ± 1.2 to 17.14 ± 1.1 kg/m^2. A significant ($P < 0.05$) improvement in the intervention group T1 was observed from 16.92 ± 1.3 kg/m^2 to 17.52 ± 1.2 kg/m^2, which represented a positive effect of the 50% bars of date pulp. BMI of the highest dose treatment group (T2) was the most affected group (17.14 ± 1.2 kg/m2 vs 17.68 ± 1.3 kg/m2), indicating the effect of the 60% date pulp bars.

Table 1. The Effect of Date Bars on Body Mass Index (BMI) Kg/m2

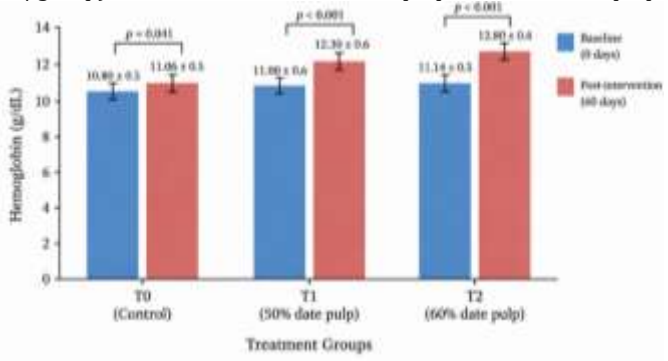
Treatment Groups	Baseline BMI (kg/m^2)	Post intervention BMI (kg/m^2)	P value
T_0 (Control)	16.58 ± 1.2C	17.14 ± 1.1C	0.004**
T_1 (50% Date Pulp)	16.92 ± 1.3B	17.52 ± 1.2B	0.003**
T_2 (60% Date Pulp)	17.14 ± 1.2A	17.68 ± 1.3A	0.002**

T0= 0% date pulp bars
T1= 50% date pulp bars
T2= 60% date pulp bars

Effect of Date Bars on Hemoglobin Levels (g/dL) of Anemic Children

The effect of date bar supplementation on hemoglobin (Hb) levels is presented in Figure 2. After the 60-day intervention, Hb levels increased in all groups, with greater improvement observed in the date pulp groups compared with the control (T0). The control group showed a slight increase from 10.80 ± 0.5 to 11.06 ± 0.5 g/dL. The 50% date pulp group (T1) improved from 11.00 ± 0.6 to 12.30 ± 0.6 g/dL, while the 60% date pulp group (T2) showed the highest increase from 11.14 ± 0.5 to 12.80 ± 0.6 g/dL. The improvement in Hb levels was significantly higher in the intervention groups than in the control ($p < 0.05$), indicating that date bars, particularly those containing 60% date pulp, may contribute to improved hemoglobin status in anemic school-going children.

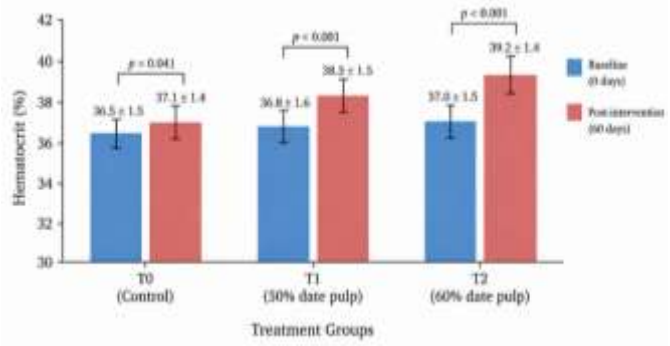
Figure 2: Effect of date bar supplementation on hemoglobin levels (g/dL) in anemic children. Values are mean ± SD (n = 20/group). T0: Control; T1: 50% date pulp; T2: 60% date pulp.



Effect of date bar supplementation on hematocrit (%) levels in anemic school-going children

Hematocrit levels increased after the 60-day intervention in all groups, with greater improvement observed in date pulp groups compared with the control. The T2 group (60% date pulp) showed the highest increase (37.0 ± 1.5% to 39.2 ± 1.4%), followed by T1 (50% date pulp) (36.8 ± 1.6% to 38.3 ± 1.5%), whereas the control group showed only a slight improvement (36.5 ± 1.5% to 37.1 ± 1.4%) (Figure 3). These findings indicate that date bar supplementation, particularly the 60% date pulp formulation, was associated with improved hematocrit levels among anemic children**.**

Figure 3: Effect of date bar supplementation on hematocrit (%) levels of anemic school-going children after 60 days of intervention. Values are presented as mean ± SD (n = 20/group). T0: control bar (0% date pulp); T1: 50% date pulp bar; T2: 60% date pulp bar.



Effect of Date Bar on Ferritin Levels (ng/mL) of Anemic Children

The results in Table 2 revealed that the levels of ferritin improved significantly during the period of date pulp consumption. There was only a slight difference in the control group (T0), which increased from 45.2 ± 2.5 to 46.1 ± 2.3 ng/mL. The representation of the T1 group (50% date pulp) ranged from 46.0±2.7 to 50.8±2.6 ng/mL, which showed a clear result on iron storage. The much important difference was recorded in the higher pulp group T2 (60% date pulp), which showed the highest amount of iron reserve (54.2±2.5 ng/mL) compared to the baseline value (46.5±2.6 ng/mL) with a highly significant difference (p<0.05).14

Table 2. Effect of Date Bar on serum ferritin values before and after intervention

Group	Baseline ferritin (ng/mL)	Post intervention ferritin (ng/mL)	P value
T_0 (Control), Mean ± SD	45.2 ± 2.5C	46.1 ± 2.3C	0.004**
T_1 (50% Date Pulp), Mean ± SD	46.0 ± 2.7B	50.8 ± 2.6B	0.001**
T_2 (60% Date Pulp), Mean ± SD	46.5 ± 2.6A	54.2 ± 2.5A	0.002**

T0= 0% date pulp bars; T1= 50% date pulp bars; T2= 60% date pulp bars

DISCUSSION

Iron deficiency anemia remains a major nutritional concern among school-going children, particularly in populations with inadequate dietary iron intake and limited dietary diversity. The present study evaluated the potential role of date (*Phoenix dactylifera L.*) bars as a functional dietary intervention for improving anemia-related hematological parameters. After 60 days of intervention, date pulp groups demonstrated greater improvements in hemoglobin, hematocrit, and serum ferritin levels compared with the control group, suggesting that date bars may support hematological improvement as part of a balanced diet. In sensory evaluation, it was observed that date pulp added to functional bars enhanced the acceptability of functional bars; the 60% date pulp formulation (T2) was the most acceptable in terms of colour, flavour, texture and overall acceptability. The results are similar to those reported by Ibrahim et al. who showed that the nutritional and sensory properties of snack bars can be improved as a result of the incorporation of dates.6 Greater acceptability can increase compliance, an important outcome of the success of school-based dietary interventions.

This observed improvement in BMI could be due to the nutritional profile and energy content of the date bars, which are rich in carbohydrates, dietary fiber, minerals, and bioactive compounds. Beware, though, of BMI changes over a short period of intervention, since many factors in diet and lifestyle change the body composition. There was a significant improvement in Hb levels, especially in the T2 group, from 11.14 ± 0.5 g/dL to 12.80 ± 0.6 g/dL.Hb level was significantly improved after intervention, especially in the T2 group (11.14 ± 0.5 g/dL to 12.80 ± 0.6 g/dL). There are precedents for the improvement in hemoglobin status after date-based interventions.[16-19]

The potential mechanism may involve the contribution of iron and other nutrients present in dates and the overall nutritional improvement provided by the functional bars. Iron in dates is mainly in the non-heme form which is less absorbable than heme iron. Therefore, the observed hematological improvements are likely due to the combined effects of dietary iron, improved nutritional intake, and bioactive components rather than iron alone. Similarly, increased hematocrit levels, particularly in the T2 group, indicate a potential improvement in erythropoietic response. Previous studies have suggested that date fruits may support hematological health due to their mineral content and antioxidant compounds.[13, 20 - 23]Consumption of date bar also resulted in an increase in serum ferritin levels which reflects the improvement in iron storage status. Ferritin, however, is an acute-phase protein and, may be affected by inflammation, and so future studies would benefit from the inclusion of inflammatory markers, such as C-reactive protein (CRP), to provide better interpretation of iron status.

Besides iron, dates are also rich in nutrients, as well. Dietary fiber, minerals, phenolic compounds and flavonoids present in dates support the antioxidant activity and nutrition quality.[24-27] In the present study, vitamin C content was not directly measured, but may have increased the absorption of non-heme iron. Hence, its bioavailability in formulating dates should be confirmed by compositional analysis of date bar formulation. This study has a number of strengths, such as the development of a culturally appropriate date based functional food, the comparison of two different concentrations of date pulp, the control group, and the assessment of several hematological parameters (hemoglobin, hematocrit, and ferritin). The results of this study suggest that date bars may be a viable dietary supplement for school-based nutrition interventions. Some restrictions, however, must be kept in mind. The sample size was relatively small, and they were recruited from one school; this could restrict the generalizability of the findings. The intervention was short-term (60 days only) and future longer follow-up studies would be needed to assess the lasting effects of hematological changes. Also, certain biomarkers were analysed but inflammatory markers, diet assessment and the nutrient content of the bars was not analysed in detail.

CONCLUSION

Conclusions are that date (*Phoenix dactylifera L.*) bars could be considered as a dietary supplement to enhance anemia-associated hematological parameters in school-going children. The 60-day intervention, particularly with 60% date pulp bars, was associated with greater improvements in hemoglobin, hematocrit, and serum ferritin levels, along with high sensory acceptability. The nutritional components of dates, including non-heme iron, minerals, dietary fiber, and bioactive compounds, may contribute to these improvements as part of a balanced diet. However, date bars should complement rather than replace clinical evaluation and established anemia management. Further large-scale and longer-duration studies are needed to confirm their role in childhood anemia.

Ethical Approval

The current work was approved by the Institution's Ethical Committee of Minhaj University, Lahore, Pakistan [Ref: MUL/CRD/23/65 dated; 12-10-2023] before progressing it.

Data Availability

The data set generated or analyzed during the current study are available from the corresponding author upon reasonable request.

Author Contributions

Qurat-ul-Ain: Conceptualization, Methodology, Data Collection & Investigation.
Uswa Ahmad & Sana Azher: Formal Analysis, Writing-Original Draft.
Iram Shahzadi & Maida Jehanzeb: Writing-Review & Editing.
All the authors read and approved the final manuscript.

Informed Consent

We obtained written informed consent from all participants before enrollment.

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No.

Conflict of Interest

No.

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Declaration of AI-Assisted Language Editing

The authors declared that no AI-Assisted Language Editing tool was used during writing and editing the manuscript.

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