

The Role of Zinc on the Reduction of PA/Zn Molar Ratio in Wheat Grains and Human Health Promotion

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INTRODUCTION

Nutrition plays an important role in human health, and Zn is a major player for a healthy nutrition. If the use of current food production methods will be continued, society's well-being might be at risk. Applying Zn-fertilizers in plant production could be essential for improving the quality of crop products. For example, the Zn content of wheat produced conventionally (imbalanced fertilization) on calcareous soils of Iran was 15 mg kg⁻¹, while U.S. wheat contained 27 mg Zn kg⁻¹. The Zn content of grains increased significantly when the same cultivar was fertilized with Zn by soil or foliar applications (balanced fertilization) (Fig. 1).

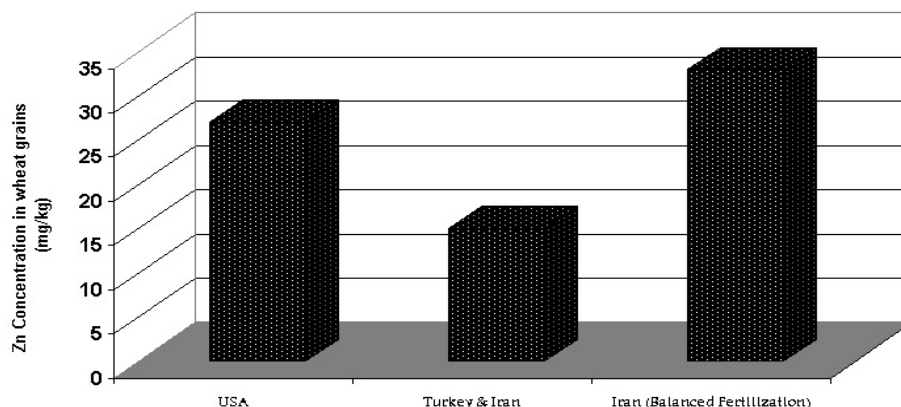


Fig. 1. Effect of Zn-fertilizer application on Zn content increase of wheat grain (Malakouti et al. 2006).

Zinc deficiency is common in agricultural products of Middle Eastern countries, including Iran and Turkey, where bread and rice are the main staple foods. Various factors result in low Zn absorption including increased levels of phytic acid that lead to high molar ratios of phytic acid to Zn (PA/Zn) in wheat grain. Conventional practices have led to Zn deficiency in plants and the human food chain. However, general awareness of this plant-human nutrition aspect hardly exists. Application of Zn-fertilizers to Zn-deficient soils has been associated with improved yield and crop quality for cereals and enhanced human health. This study was conducted to evaluate the effect of Zn application on wheat grain yield, the PA/Zn molar ratio in wheat grain, and on Zn concentrations in human blood serum after the supplementation of Zn-enriched bread.

METHODS

This study was conducted in two stages in two provinces (West and East Azarbyjan) in 2003 and 2004. In stage one, the field study was carried out on 50 ha of wheat fields (25 ha control plots and 25 ha treated plots). The control plots were fertilized with nutrients based on a soil test except for Zn. The treated plots received nutrients based on a soil test and 40 kg ha⁻¹ ZnSO₄ based on previous results. In addition, Zn-fertilizer was sprayed at the stages of stem formation, ear formation, and a week after flowering. Nutrients and soils were mixed before

planting. In stage two, the enriched wheat was stored for three months before grinding. The flour was used for bread and given to selected people in four villages for six months. Zinc concentrations in blood serum of males and females were measured before and after the intervention.

RESULTS AND DISCUSSION

The wheat grain yield increased significantly (at the 5 % level) in response to Zn application. The lowest increase in grain yield was 350 (control: 5,450 - treated: 5,800), all in kg ha⁻¹. The highest increase was 1,900 (control: 6600 – treated: 8,500), all in kg ha⁻¹. The average grain yield increase on all treated farms was 954 (control: 5,242 – treated: 6,196) all in kg ha⁻¹. These results highlight the positive Zn effect of increasing wheat yield. Zinc application significantly improved the concentration of Zn in grain and consequently reduced PA/Zn molar ratio (Table 1), similar to other findings (Erdal et al. 1998, Malakouti et al. 2006).

Table 1. The effects of treatments on Zn content and PA/Zn molar ratio in the grain.

Treatment	P	Zn	PA/Zn
Check plots	0.33 A	14.1 B	23.78
Treated plots	0.31 A	24.5 A	12.46

The diet with enriched bread for six months increased Zn concentrations in blood serum noticeably ($\alpha=0.01$) with averages of 80.05 and 109.73 $\mu\text{gram dL}^{-1}$ before and after the intervention, respectively (Table 2).

Table 2. Zinc concentrations in blood serums before and after intervention (West Azarbiejan, 2003).

Sexual groups	Zn in serum (before intervention)		Zn in serum (after intervention)	
	Mean \pm SD	Confidence interval	Mean \pm SD	Confidence interval
Male	87.92 \pm 35.72	79.46 - 96.37	108.66 \pm 44	108.66 - 43.78
Female	75.23 \pm 39.40	67.99 - 82.47	110.39 \pm 53	100.46 - 120.13
P-Value	P=0.818		P=0.028	

CONCLUSIONS

According to WHO (1996) and Gibson (1998), the PA/Zn ratio should be below 25 in food materials (e.g., bread) so that nutrients in the food can get absorbed during digestion. While the (PA/Zn) ratio in wheat grain produced on calcareous soils can exceed 40, mainly due to imbalanced fertilization and overuse of P-fertilizers, the application of ZnSO₄ considerably decreased PA/Zn ratios. Thus, by following this practice, additional yield increase, increased bioavailability of micronutrients in whole wheat bread to be absorbed into our body and human health promotion can be achieved.

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