THE INFLUENCE OF ZINC COMPOUNDS ON WHEAT, BARLEY AND OAT GERMINATION RATE

Camelia MOLDOVAN, Cristina TOȚA

Banat's University of Agricultural Sciences and Veterinary Medicine, Agrofood Products Technology Timişoara
E-mail: kmimol@gmail.com

Abstract: *Modern diets include more and more raw food or functional food products. Germs and sprout have high biological value due to the quality and quantity of nutrients. Since water is the specific biochemical medium for reactions specific to germination (conversion of proteins in aminoacids and amides, conversion of starch into maltose and glucose, conversion of lipid into fat acids), also ensuring transport of theresulted products towards embryo, the presence of chemical compounds in water may influence the germination process and the plant development, thus contributing substantially to changes in their biological potential. The purpose of this study was to evaluate the germination rate for seeds of wheat, barley and oats in the presence of zinc acetate, zinc sulfate that different doses (50 and 100 ppm zinc). Essentiality of zinc (at small and moderate doses) for plant development is indisputable, but its effect on germination rate was less studied in cereals. Germination was acomplished in laboratory conditions, and germination rate was quantified at five and ten days after the start of experiment using Saupe method. We obtained sprout from three species of grain, in the presence of acetate and zinc sulphate.To the end of the first five days, the germination rate was lower in the groups treated with zinc compounds, comparatively with the control groups (average of -5.98% and -9.02% for wheat, -14.57% and -19.62% in barley and -12.08% and -6.78% for oats). Germination rate of the three species, after ten days, was also lower in the experimental groups than in the control group (average of -1.0% and -2.45% for wheat, -4.49% and -4.16% for barley and -3.10%, respectively -0.18% in oats. An exception was noted in the group of wheat treated with 50 ppm zinc as acetate, where the germination rate has been increased to +3.59% respectively +1.05% comparing with the control groups. The dose of 100 ppm zinc, no matter which zinc chemical form was used (acetate or sulphate) affected the germination rate in a higher degree that the 50 ppm zinc dose.*

Key words**:** *germination rate, wheat, barley, oat, shoot, zinc*

INTRODUCTION

The importance of cereal germs in health is already known among consumers. Germs are young plants. Germ embryos of seeds are rich in protein, fiber, polyunsaturated fats, vitamin E, vitamin B_1, B_2, B_6, pantothenic acid, phosphorus, zinc, thiamine, magnesium, natural fiber and antioxidants. At this stage of their development, they have a higher concentration of protein, vitamins, minerals, enzymes, RNA, DNA, bioflavonoids, T cells, etc., than at any other time of their life - even compared with the mature vegetable **(**MEYEROWITZ, 2005**).**

Given the large number of essential nutrients from the germs of cereals, they bring many benefits to our health (LORENZ, 1980; CHAVAN and KADAM, 1989; MEYEROWITZ, 2005). The germs reduce blood cholesterol levels, therefore, they reduce the risk of cardiovascular problems, contribute to improve energy storage in muscle and also increase strength and vitality of the body, protect muscles, blood, lungs and eyes, prevent heart disease, cancer and aging (FAHEY et al., 1997; MEYEROWITZ, 2005).

Germ came out from seeds and sprout develops from germs.

Sprout is formed from seeds through germination. Sprout is consumed in the early growth phase, when the concentration of nutrients is very high.

Biological value of sprout came to the attention of researchers since the last decades of the last century (PENAS et al, 2008, quoted by MARTON et al., 2010), while the consumption constantly increased. Modern diets include food consumption sprout both as prevention and as medicine.

Grain sprout has also an exceptional nutritional value as an outstanding source of vitamins, minerals, enzymes and amino acids that help maintain the health of animal organisms (LORENZ, 1980; CHAVANIA and KADAM, 1989; AACR., 2005; SCHENKER, 2002 , FINLEY, 2005, WEBB 2006, quoted by MARTON et al., 2010). Small quantities of sprouts may protect against the risk of cancer as effectively as much larger quantities of mature vegetables of the same variety (FAHEY et al., 1997).

Sprouting of grains causes increased enzyme activity, a loss of total dry matter, an increase in total protein, a change in aminoacid composition, a decrease in starch (LORENZ, 1981), increases in sugars, a slight increase in crude fat and crude fiber, and slightly higher amounts of certain vitamins and minerals (LORENZ,1980; MARTON et al., 2010).

During seed germination, protein degradation occurs (in oligopeptides and amino acids), polysaccharides (in oligo- and monosaccharides), fat (in free fatty acids), biochemical processes that support mechanisms in the body; germination is considered a process of predigestion (CHAVANIA and KADAM, 1989, MARTON et al., 2010).

Also, during germination, the antinutritive components (trypsin inhibitors, phytic acid, pentosan, tannin) decreases. After germination compounds appear particularly beneficial to health (glucosinolate, antioxidants) (MARTON et al., 2010).

Nowadays, especially the Far East markets, but markets in Europe adzuki bean sprout, alfalfa, broccoli, buckwheat, clover, mungo beans, mustard, radish sprouts, sunflower, tomato and soybean (MARTON et al., 2010).

European studies on nutritional value sprout are limited (MARTON et al., 2010). Also, there are no known research on the influence of zinc compounds on the germination of cereals.

The purpose of this study was to evaluate the germination rate of seedlings obtained from seeds of wheat, barley and oats in the presence of zinc acetate, zinc sulfate in different doses (50 and 100 ppm zinc).

MATERIAL AND METHODS

For seed germination of grain were used textile germination supports over which were settled 100 seeds (wheat Lovrin 34, barley System and oat Lovrin 1 variety).

For studying the phenomena of germination it was used distilled water, potable water, acetate and zinc sulphate (50 and 100 ppm Zn).

There were six groups, two control (M and M') and four experimental (E) for each species of seed. Each group was composed from three samples of 100 seeds for each species of cereal.

The addition of zinc compounds solutions, distilled water and drinking water had place in 24 h and equal volumes for all groups of the same species.

The stages of germination were monitored throughout the germination period. Germination rate was evaluated by counting the germinated seeds and reporting the total number of seeds (100) subjected to the experiment, according to the relation (SAUPE, 2009):
%G = (number of germinated seeds / number of total seeds) x 100

Data were statistically analysed by ANOVA descriptive statistics method.

RESULTS AND DISCUSSIONS

Seed germination rate of wheat, barley and oats, in the presence of zinc compounds, after five and ten days, is shown in Table 1 and figures 1-2.

Table 1

Germination rate of wheat, oat and barley seeds, in the presence of zinc compounds, after five and ten days

	Lot	Number of days	$\bar{x}$±Sx	DS	Minim	Maxim	Confidence level 95%
Wheat	M_1 (distilled water)	5	69,66±2,403	4,163	65	73	10,342
		10	92,66±2,962	5,131	87	97	12,747
	M'$_1$ (drinking water)	5	72±4,725	8,185	63	79	20,333
		10	95±2,081	3,605	91	98	8,956
	$E_{1.3}$ (50 ppm Zn - sulphate)	5	67,333±1,027	2,054	65	70	3,269
		10	94,66±1,855	3,214	91	97	7,985
	$E_{1.4}$ (100 ppm Zn - sulphate)	5	63,66±0,881	1,527	62	65	3,794
		10	90,66±0,88	1,527	89	92	3,794
	$E_{1.5}$ (50 ppm Zn - acetate)	5	64,333±3,282	5,686	58	69	14,125
		10	96,0±0,577	1,0	95	97	2,484
	$E_{1.6}$ (100 ppm Zn - acetate)	5	62,66±0,66	1,547	62	64	2,868
		10	89,66±0,66	1,154	89	91	2,868
Barley	M_2 (distilled water)	5	74,333±1,763	3,055	71	77	7,589
		10	96,333±1,201	2,081	94	98	5,171
	M'$_2$ (drinking water)	5	79,0±2,0	3,464	77	83	8,605
		10	96,0±0,577	1,0	95	97	2,484
	$E_{2.3}$ (50 ppm Zn - sulphate)	5	66,33±1,201	2,081	64	68	5,171
		10	94,0±1,527	2,645	91	96	6,572
	$E_{2.4}$ (100 ppm Zn-sulphate)	5	60,66±1,452	2,516	58	63	6,251
		10	90,0±2,081	3,605	87	94	8,956
	$E_{2.5}$ (50 ppm Zn - acetate)	5	63,33±1,452	2,516	61	66	6,251
		10	94,33±1,66	2,886	91	96	7,171
	$E_{2.6}$ (100 ppm Zn - acetate)	5	62,66±1,201	2,081	61	65	5,171
		10	90,33±1,763	3,055	87	93	7,589
Oat	M_3 (distilled water)	5	70,333±2,403	4,163	67	75	10,342
		10	91,333±1,763	3,055	88	94	7,589
	M'$_3$ (drinking water)	5	66,33±1,333	2,309	65	69	5,736
		10	88,33±2,403	4,163	85	93	10,342
	$E_{3.3}$ (50 ppm Zn - sulphate)	5	63,33±0,881	1,527	62	65	3,794
		10	90,33±1,201	2,081	88	92	5,171
	$E_{3.4}$ (100 ppm Zn - sulphate)	5	60,33±1,855	3,214	58	64	7,985
		10	86,66±1,201	2,081	85	89	5,171
	$E_{3.5}$ (50 ppm Zn - acetate)	5	64,66±0,66	1,154	64	66	2,868
		10	89,33±1,452	2,516	87	92	6,251
	$E_{3.6}$ (100 ppm Zn - acetate)	5	63,66±0,881	1,527	62	65	3,794
		10	87,66±0,881	1,527	86	89	3,794

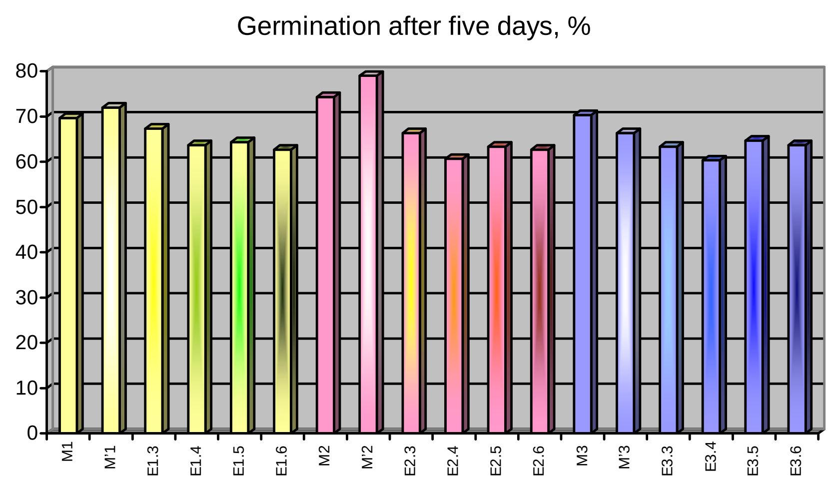

Figure 1 - Seed germination rate of wheat, barley and oats in the presence of zinc compounds, after five days

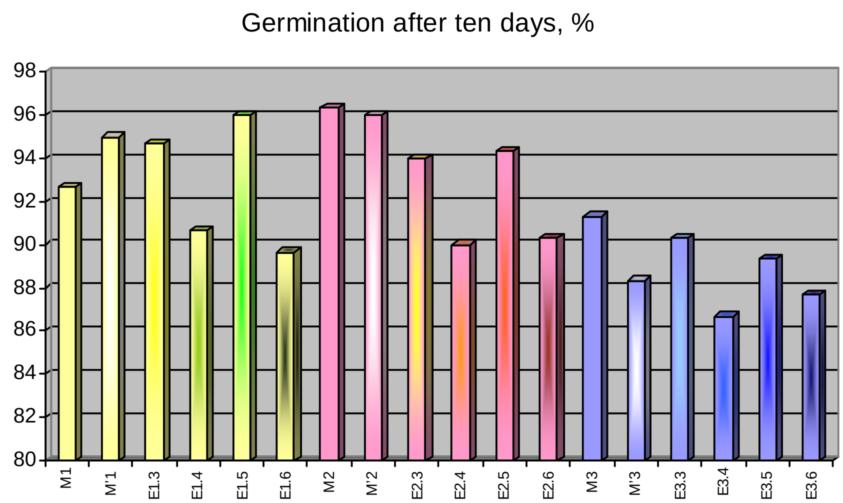

Figure 2 - Seed germination rate of wheat, barley and oats in the presence of zinc compounds, after ten days

The presence of zinc compounds reduced the germination capacity of the three cereals, quantified five days.

Thus, in wheat, germination rate was significantly reduced ($p<0.05$) in groups $E_{1.4}$ and $E_{1.6}$, compared to group M'_1 ($E_{1.4}/M'_1$: -11.57%; $E_{1.6}/M'_1$: -12.96%) and insignificant ($p>0.05$) in the other groups, compared with control groups ($E_{1.3}/M_1$: -3.34%; $E_{1.3}/M'_1$: -6.48%; $E_{1.4}/M_1$: -8.61%; $E_{1.5}/M_1$: -7.65% $E_{1.5}/M'_1$: -10.64%, $E_{1.6}/M_1$: -10.04%).

Wheat germination rate was reduced on average as follows: $\overline{X}E_1/M_1$: -5.98%; $\overline{X}E_1/M'_1$: -9.02%. Germination rate was inversely correlated with the dose applied ($E_{1.4}/E_{1.3}$: -5.44%; $E_{1.6}/E_{1.5}$: -2.59%).

In the case of barley, the influence of zinc compounds was negative in the experimental groups ($E_{2.3}$, $E_{2.4}$, $E_{2.5}$ and $E_{2.6}$) recording lower percentages (insignificant, $p>0.05$) in comparison with the control groups ($E_{2.3}/M_2$: -10,76%; $E_{2.3}/M'_2$: -16,03%; $E_{2.4}/M_2$: -18,38%; $E_{2.4}/M'_2$: -23,20%; $E_{2.5}/M_2$: -14,79%; $E_{2.5}/M'_2$: -19,83%; $E_{2.6}/M_2$: -15,69%; $E_{2.6}/M'_2$: -20,67%; $\overline{X}E_2/M_2$: -14,57%; $\overline{X}E_2/M'_2$: -19,62%). Between barley germination rate and the applied dose was established an inverse correlation ($E_{2.4}/E_{2.3}$: -8.54%; $E_{2.6}/E_{2.5}$: -1.05%).

Five days after administration of zinc compounds, oat germination rate decreased insignificantly ($p>0.05$) in all experimental groups compared with control groups ($E_{3.3}/M_3$: -9,95%; $E_{3.3}/M'_3$: -4,52%; $E_{3.4}/M_1$: -14,21%; $E_{3.4}/M'_3$: -9,04%; $E_{3.5}/M_3$: -8,05%; $E_{3.5}/M'_3$: -2,51%; $E_{3.6}/M_3$: -9,47%; $E_{3.6}/M'_3$: -4,02%; $\overline{X}E_3/M_3$: -12,08%; $\overline{X}E_3/M'_3$: -6,78%). Oat germination rate was inversely correlated with the dose of zinc, such as sulphate and the acetate ($E_{2.4}/E_{2.3}$: -4,73%; $E_{2.6}/E_{2.5}$: -1,54%).

The results were consistent with data reported by EL-GHAMERY et al., (2003). They argue that treatments with zinc reduced the germination percentages of *N. sativa* seeds and *T. aestivum* grains and inhibited the root growth of both plants. Unlike the results obtained in literature is known that small quantities of zinc in cereal seed germination and development of seedlings favors (OZTURK et al. 2006, quoted by CAKMAK, 2007) acting, particularly on the development of radicle and plumule; JADIA and FULEKAR, (2008) argue that the sorghum plants, increasing the dose of zinc (5 to 50 ppm), determined to improve its germination rate in soil.

Germination rate of wheat, after ten days, was significantly reduced ($p<0.05$) at $E_{1.6}$ compared with the control M_1 ($E_{1.6}/M_1$: -3,23%), but insignificantly ($p>0.05$) in experimental group $E_{1.4}$ compared to M_1 ($E_{1.4}/M_1$: -2,15%). In $E_{1.5}$ groups germination rate was insignificantly increased ($E_{1.5}/M_1$: +3,59%; $E_{1.5}/M'_1$: +1,05%).

Also, the germination rate decreased insignificantly ($p>0.05$) in groups $E_{1.3}$, $E_{1.4}$ and $E_{1.6}$ compared to M'_1 ($E_{1.3}/M'_1$: -0,35%; $E_{1.4}/M'_1$: -4,56%; $E_{1.6}/M'_1$: -5,61%).

The one exception was noted in group $E_{1.3}$, where it was found as increasing the germination rate compared to control group M_1 ($E_{1.3}/M_1$: +2,15%).

The average reduction of wheat germination in control groups, depending on the compound of zinc given was: $\bar{X}E_1/M_1$: -1.0%; $\bar{X}E_1/M'_1$: -2.45%, thus determining inverse correlation between germination rate and dose of zinc applied ($E_{1.4}/E_{1.3}$: -4.22% $E_{1.6}/E_{1.5}$: -6.59%) both as sulphate and the acetate.

In the case of barley, the rate of germination at ten days in the presence of zinc compounds (zinc sulfate and acetate) showed lower values in the groups treated ($E_{2.3}$, $E_{2.4}$, $E_{2.5}$ and $E_{2.6}$) than in the untreated (M_2 and M'_2).

Reductions were not significant ($p>0.05$) ($E_{2.3}/M_2$: -2.42%; $E_{2.3}/M'_2$: -2.08%; $E_{2.4}/M_2$: -6.57%; $E_{2.4}/M'_2$: -6.25%; $E_{2.5}/M_2$: -2,07%; $E_{2.5}/M'_2$: -1,73%; $E_{2.6}/M_2$: -6,22%; $E_{2.6}/M'_2$: -5,90%; $\bar{X}E_2/M_2$: -4.49%; $\bar{X}E_2/M'_2$: -4.16%).

Germination rate was in inverse correlation with the applied dose ($E_{2.4}/E_{2.3}$: -4.25%; $E_{2.6}/E_{2.5}$: -4.24%).

Compared with control groups (M_3 and M'_3), oats germination rate was significantly ($p<0.05$) lower in most experimental groups ($E_{3.3}/M_3$: -1.09%; $E_{3.4}/M_1$: -5.10% $E_{3.4}/M'_3$: -1.88%; $E_{3.5}/M_3$: -2.18%; $E_{3.6}/M_3$: -4.01%; $E_{3.6}/M'_3$: -0.75%; $\bar{X}E_3/M_3$: -3.10%; $\bar{X}E_3/M'_3$: -0.18%), except $E_{3.3}$ and $E_{3.5}$ groups compared to M'_3 ($E_{3.3}/M'_3$: +2.26%; $E_{3.5}/M'_3$: +1.13%).

Oat germination rate was in inverse correlation with the dose of zinc applied both as sulphate ($E_{3.4}/E_{3.3}$: -4.05%) and acetate ($E_{3.6}/E_{3.5}$ -1.86%).

CONCLUSIONS

Research on the germination rate of seedlings of wheat, barley and oats, consecutive treatment with zinc acetate or zinc sulfate showed:

- after five days:
  - reducing germination rates of wheat, barley and oats in the experimental groups compared with control groups;
  - inverse correlation of the germination rates with zinc doses applied sprouting (germination rates were better in groups treated with 50 ppm than at 100 ppm zinc);
  - negative influence of zinc compounds at doses of 50 or 100 ppm zinc regardless of chemical form of zinc (acetate or sulphate).
- after ten days:
  - lower germination rates in experimental than in control, regardless of dosage and chemical form of zinc applied;
  - in five days the germination rate was significantly reduced in the experimental groups, the effect of the zinc compounds after ten deys obvious.

Doses of 50 or 100 ppm zinc proved too large for a positive effect over the germination of these three cereal species.

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