ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA

VOL. XXXI(1) SECTIO EE 2013

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Ozone disinfection of feed wheat

Dezynfekcja ozonem pszenicy paszowej

Summary. The research objective was to determine the ozone effect on molds colonizing wheat grains. The ozone used in the experiment was produced by an ozone generator. The wheat grain exposure time to ozone was 0.5, 1, 3, 6 and 9 h, respectively. The studies showed ozone to effectively control molds colonizing wheat grains. The studies established the exposure time resulting in the lowest reduction rate of microorganisms as well as ozonation treatment time required to attain the highest level of grain disinfection be safely administered to animals.

Key words: ozonation, wheat grain, mold fungus

INTRODUCTION

The requirements concerning the safety and quality standards of raw material including cereal grains have been steadily increasing and that necessitates the search for novel and more effective disinfection methods. Importantly, consumers demands escalated for new preservation technologies in the food industry to inactivate harmful microorganisms, i.e. to reduce pathogen load needed for the food to be safe, and do not produce any adverse byproducts. Whereas agricultural producers' and particularly cereal crop farmers' intention is to obtain the best possible crop and in turn, economic performance [Sağir and Yildiz 2004, Gajęcka *et al*. 2008, Wang *et al*. 2008].

Mold fungi influence negatively the quality of cereal grains due to the generation of harmful mycotoxins in grains, followed by contamination of ready products manufactured, and thus, pose a health challenge. Furthermore, they deteriorate nutritional quality of grains, reduce their storage quality that affect as many as 4% of stored grains annually and may be even higher when grains are exposed to unfavorable environmental conditions, like high temperature and air humidity. Infected grain is a source of workers' expo-

sure to bioaerosols during harvesting [Tylkowska *et al*. 2007, Gajęcka *et al*. 2008, Tančinová and Labuda 2009, Szwajkowska-Michałek *et al*. 2010].

Infected grain used as seed, it will not can guarantee high yields of crops. The poor state of the seeds also contributes to environmental pollution fungi and their toxins, which reduces the sanitary condition of the housing of livestock. Therefore, the cereal grain disinfection issues are of paramount importance as they provide improvement of grain health status through the elimination of undesirable flora and protection against harmful byproducts generation. It will also reduce the exposure of individuals employed in the treatment of fungi and their toxins [Varga and Tóth 2005, Saeger *et al*. 2006, Singh *et al*. 2008, Munkvold 2009, Nowakowicz-Dębek *et al*. 2011]. The research objective was to evaluate effect of the ozone process on mold fungal reducibility in wheat grain.

MATERIAL AND METHODS

The experimental material comprised wheat grain harvested in 2009. Grains were treated with ozone produced by an ozone generator of 100 mg/h capacity (manufacturer data). The ozonation treatment included the following stages:

– 25g wheat grain sample prepared as the control placed in sterile container;

– 5 samples of 25 g wheat grains prepared to make the collective sample;

– during ozone process, after preset time (0, 0,5, 1, 3, 6 and 9), grain samples prepared and placed into sterile container.

The samples prepared in this way underwent the microbiological evaluation to establish total count of mold fungi. The study involved whole grains and milled ones after the ozone processing. The inoculation was carried out on the Martin's peptone-glucose agar with rose bengal in compliance with the standard PN-R-64791. The dishes were incubated at 25^{o}C temperature for 7 days. The quantitative determinations were performed at three replications and the results presented as the average fungal count expressed in CFU per 1 g of the analyzed material (CFU/g) and as log indicator reduction RF.

RESULTS AND DISCUSSION

Health of seeds is associated with the presence or absence of such pathogenic organisms like fungi, bacteria and their toxins. Bad feed can pose a threat to animal health. Therefore, disinfection of cereal grains proves to be of prime importance as it contributes to improved grain quality through removal of undesirable flora and protection against byproduct occurrence [Saeger *et al*. 2006, Krosowiak *et al*. 2007].

Ozone gas makes an alternative for commonly used disinfectants. It is a very powerful oxidant with a redox potential of 2.07 and coefficient of disinfection concentration (CT = disinfectant concentration x contact time), thus being a first choice for oxidation or disinfection [Solecka 2005, Krosowiak *et al*. 2007].

The research results are summarized in Fig.1 and Tab.1. Both, whole grain samples and those milled after the ozonation treatment showed reduced mold fungi contents as compared to the control. The obtained results served as basis for calculating ozone performance in removing mold fungi colonizing wheat grains.

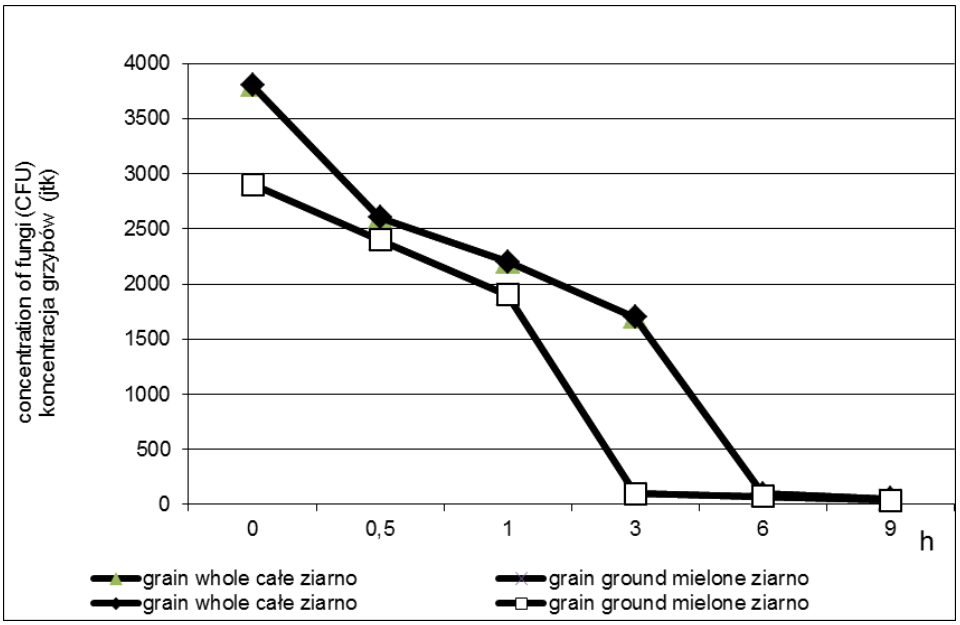

Fig. 1. Total number of fungi before and after ozonation in 1g and ground whole grain (CFU/g)
Rys. 1. Ogólna ilość grzybów przed i po ozonowaniu w 1 g całego i mielonego ziarna (jtk/g)

Table 1. The concentration of fungi in wheat grain before and after disinfection (log CFU)
Tabela 1. Koncentracja grzybów w ziarnie pszenicy przed i po dezynfekcji (log jtk)

Ozonation time (h) Czas ozonowania	Grain of wheat – Ziarno pszenicy			
	grain whole log CFU całe ziarno log jtk	grain ground log CFU mielone ziarno log jtk	log indicator reduction RF log wskaźnik redukcji RF	
			grain whole całe ziarno	grain ground mielone ziarno
0	3,58	3,46	-	-
0,5	3,41	3,38	0,16	0,08
1	3,34	3,28	0,24	0,10
3	3,23	1,99	0,35	1,29
6	2,00	1,86	1,58	0,13
9	1,73	1,56	1,85	0,31

The present studies revealed that the lowest, efficacy of whole grain disinfection was achieved after 0,5 h ozonation (Fig. 1). Content of fungi in samples of whole grains after 0,5 h disinfection was log 3,41 CFU (Tab. 1).

An alternative for widely used disinfectants is application of ozone gas. It is a powerful oxidant with a high redox potential and coefficient of disinfection concentration as compared to other disinfectants commonly used.

The studies conducted on both, whole grain samples and those milled after the ozonation process showed reduced mold fungal load as against the control group (Fig. 1). The research results served as basis for determination of log reduction factor RF (Tab. 1). It was observed that the exposure to ozone over longer period of time causes higher mold fungal reducibility. The grain milling operation was found to contribute to reduced contamination level. The obtained results confirmed the oxidizing properties of ozone and its high efficiency in removing mold fungi. Ozone gas has been shown to destroy and delay the growth of harmful microorganisms that colonize the grain surface. Thus, seed storage time can be extended and animal feed safety ensured.

The research results have confirmed the oxidizing properties of ozone and its efficiency in mold fungi elimination. It destroys microorganisms and delays their growth on grain surface and thus, allows to extend seed storage time as well as safe consumption. The quality of grains processed by ozone did not change [Cichocki 2010].

Ozonation treatment proves to an effective removal method for mold fungi and consequently, reducing their occurrence in flour. The findings of the microbiological evaluation of wheat flour indicate that the obtained mold elimination rate reached 75-80% as against grains treated with chlorinated water. Generally, the use of ozone as a natural disinfectant is becoming more common in many branches of the food industry [Szwolak 2008, Zawadzki 2009, Wang *et al*. 2008].

Ozone through the fungal content reduction contributes to the diminishment of harmful mycotoxins load in cereal grains and the products. Due to ubiquitous nature of mold fungi, eliminating them from the cereal grains and products is a virtually impossible task, yet substantial reduction through the use of, among others, ozone is possible [Jurga 2009]. In contact with the grain surface, ozone splits and disinfects the surface without changing its utility features. It absorbs better and disinfects more efficiently moisture conditioned seeds of low pH, exhibiting the highest degradation rate towards trichothecene mycotoxins [Broda and Grajek 2009]. The Japanese studies on the effect of gas ozone on different foods showed the highest efficacy of cereal grain disinfection at ozone concentration 5 ppm and a low temperature [Naito and Nanba 1987].

Owing to the fact that ozone used to destroy harmful microorganisms, leaves only oxygen as a byproduct, a potentially negative influence of this gas on organism has still remained unknown. The use of ozone as an antimicrobial agent for food treatment, storage and processing, among others as bottled water additive, was approved as GRAS (generally regarded as safe) by the US FDA (Food and Drug Administration) twenty six years ago. The FDA experts confirmed the ozonic application as disinfectant at food production only if used consistently with the Good Manufacturing Practices [Dzwolak 2008].

The present researches showed that grain exposure to ozone can efficiently reduce mold fungi. Currently, numerous factors, among others, changes in soil cultivation methods, new nutrition trends or stringent requirements at food production have given a high priority to improvement of grain disinfection technologies in the agricultural-food industry and animal feed. It is associated with special requirements for cereal grain treatment reducing harmful microflora which has adverse effect the cereal products quality and animal health.

CONCLUSION

1. Gas ozone treatment of grain decreases mold fungi colony counts in the analyzed research material and the feed is safer for animals.

2. Grain exposure time to ozone determines the efficacy of a grain disinfection process.

3. Diminution of grain reduces total fungal counts in the research material during of the ozone process.

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Streszczenie. Przedmiotem przeprowadzonych badań było wykazanie wpływu działania ozonu na grzyby pleśniowe zasiedlające ziarna pszenicy. W tym celu użyto ozonu, wytworzonego generatorem ozonu. Czas ekspozycji ziarna na ozon wynosił odpowiednio 0,5, 1, 3, 6, oraz 9 godzin. W wyniku przeprowadzonych badań stwierdzono, że ozon działa destrukcyjne na grzyby pleśniowe zasiedlające ziarna pszenicy. Oznaczono czas, po którym następuje najniższy stopień redukcji mikroorganizmów oraz czas ozonowania, który pozwala na najefektywniejszy poziom dezynfekcji ziarna, aby bezpiecznie podawać je zwierzętom.

Słowa kluczowe: ozonowanie, ziarno pszenicy, grzyby pleśniowe