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CHOICE OF DISINFECTION METHOD FOR TRITICALE GRAIN IN THE PROCESS OF SPROUT PRODUCTION

Abstract. The growing demand for food resources has led to increased interest in using unconventional cereal crops in the production of various food and beverage products. One crop that has attracted significant attention from researchers is triticale, a unique hybrid. An important area in the production of functional foods is the use of raw materials such as sprouted grains. Sprouted grains are highly nutritious and rich in vitamins, minerals, and antioxidants, making them functional foods. However, during the sprouting process, there is active growth of all types of epiphytic bacteria, microscopic fungi as well as phytopathogenic fungi found in the germ zone, which can produce mycotoxins. Therefore, ensuring the microbiological safety of sprouted grains is particularly important. The aim of this study was to select an effective method for disinfecting organic triticale grain during sprouting. Potassium permanganate and hydrogen peroxide solutions were used as disinfectants. The research found that ensuring the microbiological safety of sprouted triticale grain can be achieved by treating it with a 5% hydrogen peroxide solution.

Keywords: triticale, sprouting, disinfection, microflora, grain.

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Introduction. Triticale is a unique crop obtained through the hybridization of wheat and rye. Initially, triticale was used as a fodder crop and in the production of ethanol. However, the growing demand for food resources has expanded its use for producing dietary baked goods, pasta, malt, alcoholic beverages, yogurt [1-4].

Recent trends highlight the use of sprouted triticale grains in functional foods due to their high nutritional value, richness in vitamins, minerals, and antioxidants [5,6].

Scientific literature [7,8] reports on the therapeutic and preventive effects of sprouts on the human body, as well as their antidiabetic, anticancer, and antioxidant properties [9,10]. According to existing recommendations, the length of sprouts in grains used for food should not exceed 2 mm, as this length is associated with the highest biological value of the grain [11-13].

Cereal crops contain a complex microflora, which is concentrated primarily in the epiphytic layers of the grain and the germ, and it actively develops during the sprouting process. The soaking stage plays a key role in terms of microbiological safety, as it promotes the intensive multiplication of microorganisms, which continues during grain sprouting. During sprouting, the viable count of bacteria, microscopic fungi, and yeasts reaches its maximum [14,15]. For instance, the number of microscopic fungi increases by 2.5-5 times, yeasts by 5-10 times, and bacteria by 50-100 times [16].

In this regard, ensuring microbiological safety during the production of sprouted grains is an important and relevant task. There are various methods for reducing the microbial contamination of grains. These include physical (thermal and radiation) and chemical (oxidizers, fumigants, enzyme inhibitors, and mycotoxins) methods [17,18]. Seed disinfection is carried out using various reagents such as sodium hypochlorite [19], chlorine dioxide, peroxy acids, caprylic-capric and lactic acids, glycerol monolaurate [20], acetic acid [21], chlorophyllin salts [22], and others.

However, the decontamination methods used for grains are not always effective and safe, and the proposed new methods are difficult and not always feasible to implement [23]. Moreover, the use of many reagents is not allowed in organic production.

The aim of this study is to select an effective and safe method for disinfecting organic triticale grain during sprouting.

Materials and methods. The research was conducted in the laboratory of the S. Seifullin Kazakh Agrotechnical University. Triticale grain of the “Dauren” variety with a moisture content of 9.0±0.1%, produced under organic conditions, was used for the experiment. Potassium permanganate and hydrogen peroxide solutions, which are permitted for use in organic production, were used as disinfecting agents [24].

The total microbial contamination of the grain was determined using standard methods [25,26], and the number of microorganisms was expressed as the colony-forming units per gram of raw material (CFU/g). The obtained microbiological data were compared with the requirements of the Customs Union Technical Regulation TR CU 021/2011 “On Food Safety” [27].

The triticale grain was inspected, contaminants and foreign substances were removed, and it was then washed in running water at a temperature of 20±2°C with three repetitions. Disinfection was carried out for 20 minutes in a 0.02% potassium permanganate solution and in a 5% hydrogen peroxide solution, followed by rinsing in distilled water. Soaking in distilled water was performed for 6 hours, after which the water was drained using a sieve. The grain was then placed in containers with perforated and covered filter paper bottoms for sprouting. Previous studies had determined the optimal conditions for sprouting triticale grain (temperature 20°C, duration 36 hours). Under these conditions, the sprout length did not exceed 2 mm.

Sprouting for 24 hours was found to be insufficient for the emergence of sprouts, while at 48 hours, the sprout length exceeded 5 mm. The obtained triticale

sprouts were washed in distilled water and dried at 40°C for 24 hours. The process of obtaining triticale grain sprouts is illustrated in Figure 1.

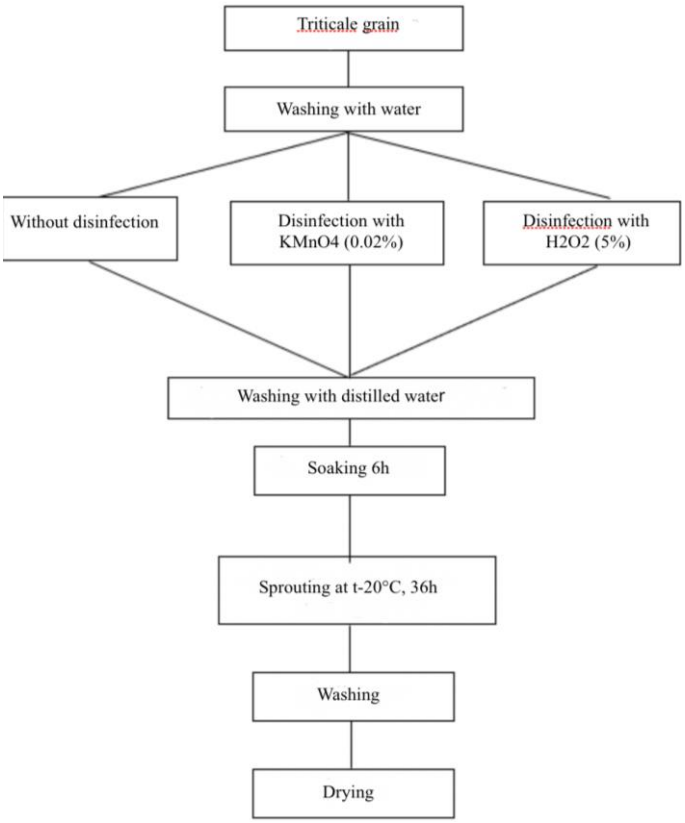

Fig.1. Scheme for obtaining sprouted triticale grains

Research results and discussion. The quantitative composition of the microflora was assessed in the initial dry grain sample (Sample 1), in the sample with water without treatment (Sample 2), in the sample treated with a 0.02% potassium permanganate solution (Sample 3), and in the sample treated with a 5% hydrogen peroxide solution (Sample 4). The results of the quantitative composition of the microflora in triticale grain during sprouting in disinfecting solutions are presented in Table 1.

Table 1

Quantitative Composition of Microflora in Triticale Grain During Sprouting in Disinfecting Solutions

Name	Microbiological indicators	
	tMAFAnM, CFU/g	Microscopic Fungi, CFU/g
Regulated Indicators According to TR CU 021/2011	No more than 5×10^4	5×10
Sample 1: Initial Dry Grain	$5{,}0\times10^5$	2,9×10
Sample 2: No Treatment (Water)	$8{,}5\times10^6$	7,5×10
Smple 3: Treatment with a 0.02% $KMnO_4$ Solution	$7{,}1\times10^6$	5,3×10
Sample 4: Treatment with a 5% H_2O_2 Solution	$4{,}8\times10^4$	1,2×10

The research established that the total number of mesophilic aerobic and facultative anaerobic microorganisms (referred to as cMAFAnM) in the initial dry triticale grain (Sample 1) was 5.0×10^5 CFU/g and the number of microscopic fungi was 2.9×10 CFU/g. When the grain was sprouted in water without treatment (Sample 2), cMAFAnM increased from 5.0×10^5 CFU/g to 8.5×10^6 CFU/g, and the number of microscopic fungi increased from 2.9×10 CFU/g to 7.5×10 CFU/g, which is associated with their active growth during sprouting. Disinfection of triticale grain in a 0.02% potassium permanganate solution resulted in a slight reduction in cMAFAnM and in microscopic fungi. Treatment with a 5% hydrogen peroxide solution (Sample 4) significantly reduced cMAFAnM to 4.8×10^4 CFU/g andthe number of microscopic fungi to 1.2×10 CFU/g.

The data on the germ zone of triticale grain after treatment with reagents are presented in Figure 2, with water treatment used as the control.

Fig. 2. Microbiological analysis of the germ zone of triticale grain: A – treatment with water, B – treatment with a 0.02% $KMnO_4$ solution, C – treatment with a 5% H_2O_2 solution

The research revealed that the germ zone of triticale was affected by various types of microorganisms, primarily microscopic fungi, as shown in Figure 2 (A). When the grain was treated with water, 100% of the grain was found to be infected with microscopic fungi and bacteria. Treatment with potassium permanganate reduced the number of microorganisms affecting the germ zone to 42.8%. Treatment with hydrogen peroxide resulted in complete disinfection.

The study concluded that treating triticale grain with a 0.02% potassium permanganate solution slightly reduces the total number of epiphytic microorganisms, but the results do not meet the safety requirements of TR CU 021/2011. Furthermore, potassium permanganate at the tested concentration did not completely eliminate microorganisms affecting the germ zone of the grain. Thus, the tested concentration of potassium permanganate solution is insufficient for disinfecting grain during sprouting.

The use of hydrogen peroxide at a 5% concentration showed the best results. These findings are consistent with studies reported in the scientific literature [28], which indicate that the use of 3% hydrogen peroxide does not reduce the number of epiphytic microorganisms to an acceptable safety level, whereas the use of hydrogen peroxide at concentrations above 6% is relatively effective [29]. Additionally, the use of hydrogen peroxide effectively eliminated microorganisms affecting the germ zone.

Conclusion. Thus, the assessment of microbial contamination in triticale grain after sprouting established that the use of a 5% hydrogen peroxide solution for pre-treatment provides maximum reduction of overall microbial contamination in both the epiphytic and germ zones of the triticale grain. The results obtained comply with the microbiological safety standards for grain as set by TR CU 021.

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КӨШЕТТЕРДІ АЛУ ПРОЦЕСІНДЕ ТРИТИКАЛЕ ДӘНІН ДЕЗИНФЕКЦИЯЛАУ ӘДІСІН ТАҢДАУ

Аңдатпа. Азық-түлік ресурстарына сұраныстың артуы әртүрлі тағамдар мен сусындар өндірісінде дәстүрлі емес дәнді дақылдарды пайдалануға деген қызығушылықтың артуына әкелді. Тритикале дақылы зерттеушілердің үлкен қызығушылығын тудырады. Функционалдық бағыттағы тамақ өнімдерін өндірудегі

өзекті бағыттардың бірі дәнді дақылдардың көшеттері сияқты шикізат ресурстарын пайдалану болып табылады. Өскен дәндердің тағамдық құндылығы жоғары және дәрумендердің, минералдардың, антиоксиданттардың едәуір мөлшері болады, сондықтан олар функционалды тағамдарға жатады. Алайда, өну процесінде эпифитті бактериялар мен микроскопиялық саңырауқұлақтардың барлық түрлерінің, сондай-ақ микотоксиндердің өндірушілері бола алатын ұрық аймағында орналасқан фитопатогенді саңырауқұлақтардың белсенді өсуі байқалады. Осыған байланысты өскен дәндердің микробиологиялық қауіпсіздігін қамтамасыз ету ерекше өзекті болып табылады. Бұл зерттеудің мақсаты өну кезінде тритикале органикалық дәндерін дезинфекциялаудың тиімді әдісін таңдау болды. Дезинфекциялаушы ретінде калий перманганаты мен сутегі асқын тотығының ерітінділері қолданылды. Зерттеулер нәтижесінде өскен тритикале дәнінің микробиологиялық қауіпсіздігін қамтамасыз етуге сутегі асқын тотығының 5% ерітіндісімен өңдеу арқылы қол жеткізуге болатындығы анықталды.

Тірек сөздер: тритикале, өну, дезинфекция, микрофлора, астық.

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ВЫБОР СПОСОБА ОБЕЗЗАРАЖИВАНИЯ ЗЕРНА ТРИТИКАЛЕ В ПРОЦЕССЕ ПОЛУЧЕНИЯ ПРОРОСТКОВ

Аннотация. Растущий спрос на пищевые ресурсы привел к повышенному интересу использования нетрадиционных зерновых культур в производстве различных продуктов питания и напитков. Большой интерес исследователей вызывает уникальная культура – тритикале. Одним из актуальных направлений при производстве продуктов питания функциональной направленности является использование таких сырьевых ресурсов как проростки зерновых культур. Пророщенные зерна обладают высокой питательной ценностью и значительным количеством витаминов, минералов, антиоксидантов, поэтому они относятся к функциональным продуктам питания. Однако во время процесса проращивания происходит активный рост всех видов эпифитных бактерий и микроскопических грибов, а также фитопатогенных грибов, находящихся в зародышевой зоне, которые могут быть продуцентами микотоксинов. В связи с чем, особенно актуальным является обеспечение микробиологической безопасности пророщенных зерен. Целью данного исследования являлся подбор эффективного способа обеззараживания органического зерна тритикале при проращивании. В качестве обеззараживателей использовались растворы перманганата калия и перекиси водорода. В результате исследований установлено, что обеспечение микробиологической безопасности пророщенного зерна тритикале может быть достигнуто путем обработки 5% раствором перекиси водорода.

Ключевые слова: тритикале, проращивание, обеззараживание, микрофлора, зерно.