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Investigating Ochratoxin-A Biodegradation, Detoxification, and Antibiotic Resistance Ability of *Brevundimonas naejangsanensis*

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ABSTRACT

Ochratoxin A (OTA) is a nephrotoxic and genotoxic mycotoxin produced by *Aspergillus* and *Penicillium* species. It threatens animal and human health by contaminating feed and food commodities. Biodegradation is the most widely utilized method for detoxifying this mycotoxin. *Brevundimonas naejangsanensis*, in this paper, is capable of to degrade 60% was reported to biodegrade 60 % of OTA at 4 mg/l during the first day, 85% on the second day, and almost 99-100 % at the end of the third day when using 10 ppm of OTA. The capacity of *B. naejangsanensis was examined* to break down OTA at 28 and 30 °C in LB medium at concentrations of 4 ppm and 10 ppm. Under these circumstances, *B.* naejangsanensis was able to degrade almost 100% of OTA starting at a concentration of 10 (g/ml). *B. naejangsanensis* eliminated an average of 0.1008 and 0.05455 (g/ml/h) of OTA from a medium having an initial concentration of 4 (g/ml) at 28 and 30 °C, respectively. At both incubation temperatures, Ochratoxin A was halted significantly by *B. naejangsanensis* at both log phase and after finishing the log phase of cell development. According to the results, OTA was decomposed by *B. naejangsanensis* to ochratoxin of lower toxicity. At the same time a strain of microorganism was being tested for its antimicrobial potential, with tests demonstrating that such resistance might be achieved. The antibiotic susceptibility of a *B. naejangsanensis* strain isolated from soil samples was evaluated against a range of unrelated antibiotic drug classes. *A. calcoaceticus* was resistant to most of the antibiotics. Through the use of several methods, including high-performance liquid chromatography (HPLC), the toxin's breakdown was tracked.

Keywords- OTA, biodegradation, detoxification, antibiotic, resistance.

I. INTRODUCTION

According to Stark (1980), Malir et al. (2006), Wild and Gong (2009), Krifaton et al. (2010) and Kensler et al. (2011), mycotoxins are secondary fungal metabolites that have oestrogenic, hepatotoxic, haemorrhagic, nephrotoxic, neurotoxic, teratogenic, mutagenic, and carcinogenic effects on both people and animals. One of the most significant mycotoxins is OTA, which is produced by genera of *Penicillium* and *Aspergillus* species. OTA is stable even at high temperature and resistant to hydrolysis. During food and feed processing OTA contamination level is not reducing, and it can be found intact in the final products (Zimmerli and Dick 1995, Vega et al. 2006). OTA is considered to be one of the most important contaminants which occurs in cereals, peanuts, coffee beans, red wine, meat, eggs, and milk products (Bragulat et al. 2008, Duarte et al. 2012). There are several data, that OTA has the highest oral bioavailability in humans, approximately 93% (Kőszegi-Poór 2016). In addition, OTA can be found in human blood (Scott et al. 1998) and mostly

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excreted in urine (Vatinno et al. 2007). In farm animals OTA reduces growth performance, raises veterinary care cost and negatively affects the immune system (Zain 2011). The International Agency for Research on Cancer (IARC) has classified OTA as group 2B possibly carcinogenic to humans (IARC 1993).

Main target of OTA in animals and humans is kidney, for instance, OTA was detected in biopsy kidney sample of a human patient having a chronic interstitial nephropathy, moreover increasing level of OTA in the blood was also detected (Maaroufi et al. 1994). Likewise, low concentrations of OTA in rat kidneys proved to up-regulate gene expression of organic anion transporters isotypes (Žlender et al. 2009). One study reported that OTA might also cause damage to the DNA of human kidney cells (Yang et al. 2014), promotes the development of collagen in human embryonic kidney cells (Hennemeier et al. 2014) and may cause precocious senescence of renal proximal tubules (Yang et al. 2017).

There are several strategies concentrating on the reduction and/or elimination of OTA concentration in animal feeds and foods intended for human consumption. Physical methods of decontamination may be used to lower or eliminate the OTA content in a feed or food product. Imposition if physical adsorbents methods are common practice far reaching adverse effects include the non-specific dish of certain crucial nutrients (like vitamins, minerals etc.). Other biological controls for instance are however comparatively more effective as they help in the mitigation of OTA contamination in feed thus reducing the risks posed to animal and human health. Simple rehabilitation is possible over a third of bacterial strains enumerated in Table 1. Are characterized by their very high efficiency towards OTA biodegradation. Analytical and immunological methods are not methods with sufficient ability to assess biodegradation ability This is due to their limitations and the inability to detect toxic effects of decomposed products and metabolites compounds, including (resulting from natural life cycle and biodegradation), as biodegradation does not represent full detoxification ability Going back to the scientific recommendations issued by the European Food Safety Authority (EFSA) issued in 2010 and there is a need to develop and apply new toxicological strategies within the organism to prove the effectiveness of biodegradation and direct detoxification. There are bio-tests for investigating the biodetoxification potential of different microbes, such as Ames test (Alberts et al. 2006, Teniola et al. 2005), for measuring mutagenicity or SOS-Chromo test for testing genotoxcicity of AFB1 (Krifaton et al. 2011), or BLYES test for testing estrogenicity in the case of ZEA and their by-products (Krifaton et al. 2013). However, there is no available bio-test for measuring the effectiveness of the biodegradation metabolites for OTA. Fuchs and colleagues (Fuchs et al. 2008) developed a micronucleus (MCN) assay based on the effect of by-products of a Lactobacillus acidophilus strain on HepG2 liver cells. They found that the by-product caused a significant reduction in MCN-frequencies and also reduced the inhibition of cell division, but should be mentioned that the main target organ for OTA is the kidney and not the liver. This paper aims to measure the biodegradation of OTA by B. *naejangsanensis* and antibiotic resistance.

Table 1. List of bacteria strains biodegrading OTA

Bacteria	OTA concentration and incubation time	Biodegradation ability	Biotechnological test	Reference
Alcaligenes faecalis	5 µg/mL in 48h	68% (aerobic)	No	Beard et al. 1996
Lactobacillus acidophilus	100 - 300 µg/mL in 4h	95% (anaerobic)	MCN assay on HepG2 cells	Fuchs et al. 2008
Bacillus spp.	5 mg/l in 3days	92.5% (aerobic)	No	Petchkongkaew et al. 2008
Brevibacterium casei	40 µg/L and 40 mg/L, in 10 days,	100% (aerobic)	No	Rodriguez et al. 2011
Cupriavidus basilensis OR16	2 µg/ml and 10 µg/ml in 3 days	97% (aerobic)	Feeding experiment on mice	Ferenczi et al. 2014
Pediococcus parvulus	1 µg/mL in 7 days	97% (anaerobic)	No	Abrunhosa et al. 2014
Bacilus amyloliquefaciens ASAG1	1 µg/mL	97% (aerobic)	No	Chang et al. 2015
Acinetobacter sp. neg1 and Acinetobacter calcoaceticus 396.1	1 µg/mL	92% in six days, (aerobic)	No	De Bellis et al. 2015
Acinetobacter sp.neg1, ITEM 17016	1 µg/mL in 144h	70% (aerobic)	No	Luz et al. 2018
Lactobacillus johnsonii CECT 289	0.1 and 1000 µg/L, in media	97% (aerobic)	No	Zhang et al. 2017

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II. MATERIAL AND METHODS

2.1. Reagents

The study worked on the traditional Luria-Bertani (LB) method, which consists of 100% of the basic components and is divided according to the following and study shows this: 10 g of tryptone with 5 g of yeast product, with the addition of 9 g of sodium chloride, with the use of modified Luria-Bertani medium. At a rate of 20%, it contains a ratio of 2 g of tryptone to 1 g of yeast extract mixed with 1.8 g of sodium chloride. (BioLab Budapest, Hungary).

The author also used ochratoxy A (OTA), which was brought from Sigma-Aldrich (USA) and is known to be a compound known for its toxic effects. In addition, methyl ester methane sulfonate (MMS) was also used from Sigma-Aldrich (USA), which is known to have toxic effects and it is a chemical substance used in studies related to toxicity and for the purposes of genetic analysis. Operators for the experiments were requested from the company Integrated DNA Technologies located in Hungary to support the research.

2.2 Bacterial strain and culture conditions in the biodegradation experiment

The *Brevundimonas naejangsanensis* sp. nov is a strain of Proteobacteria that is rare to isolate from clinical samples but is widely found in soil and is classified as Gram-negative and it was obtained by isolating it in Hungary where it was first classified by Kang and colleagues in 2009 (Kang et al., 2009).

The strain being studied was cultivated on LB agar plates and incubated at 28 °C for 48 hours. We inoculated the colonies into 50 ml of liquid LB medium post-incubation, allowing the strain to proliferate at 3 g for an additional 48 hours. This growth was assisted by measuring the optical density (OD) at a wavelength of 600 nm, using an IMPLEN spectrophotometer (GENESIS 10S, Thermo Fisher Scientific, USA). The optical density was adjusted to 0.6 to standardize conditions for subsequent experiments. After reaching the desired OD, 5 ml of the suspension was transferred to 45 ml of modified LB medium (20% concentration), and this process was repeated. Three times. To evaluate the effects of ochratoxin A (OTA), it was added at concentrations of 4 mg/L and 10 mg/L. OTA was initially dissolved in methanol to achieve the required concentrations in the medium.

Three independent control groups were created: the uninoculated negative control containing 4 mg/L and 10 mg/L OTA without strain and the positive control without OTA which comprised strain culture with 10 mg/L methyl methyl sulfonate (MMS) to test the strain's reaction in Absence of OTA Samples were cultured at 3 g and 28 °C for 3 to 5 days. On the third day, marking the end point of the experiment, all remaining materials were harvested. This involved centrifugation at 25,000 g at 4°C for 20 minutes to separate the supernatant from cellular debris and to ensure bacteriological sterility. The ultrafine liquid was filtered using 0.2 μm syringe filters (VWR International Ltd., Hungary). This step was critical to eliminate No microbial contamination while preserving the “natural metabolic products” generated during biological tests. Residual OTA concentrations in superfluid and sediment were analyzed using high-performance liquid chromatography (HPLC), allowing accurate assessment of the effect of biodegradation and resulting metabolic reactions.

2.3 Molecular identification of the strain.

DNA of *B. naejangsanensis* was isolated in triplicate by using the Bacterial Genomic Miniprep Kit (Sigma Aldrich) (Figure 1).The strain molecular characterization was done through 16S rDNA sequencing and it was achieved with the help of PCR using the universal primers 27F (5’-AATGGGCGCAAGCCTGAT-3’) and 1492R (5’AGAAAGGAGGTGATCCAGCC-3’) (Kang et al., 2009) (Figure1). To purify the PCR product, a QIAquick PCR Purification kit (Qiagen) was applied. According to the recommendations, sequencing of purified 16S rDNA products amplified by PCR was performed with an ABI PRISM BigDye Terminator Cycle Sequencing Ready Reaction kit (Applied Biosystems).

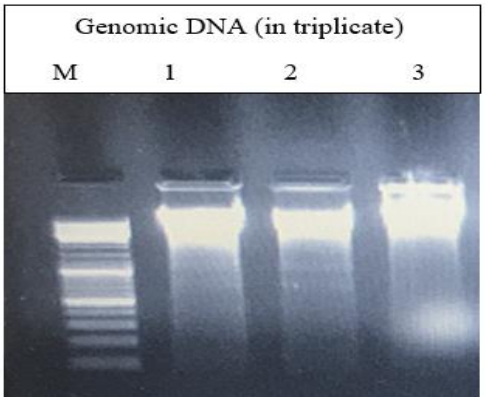

Figure 1: Genomic DNA isolation of *B. naejangsanensis,* M=marker

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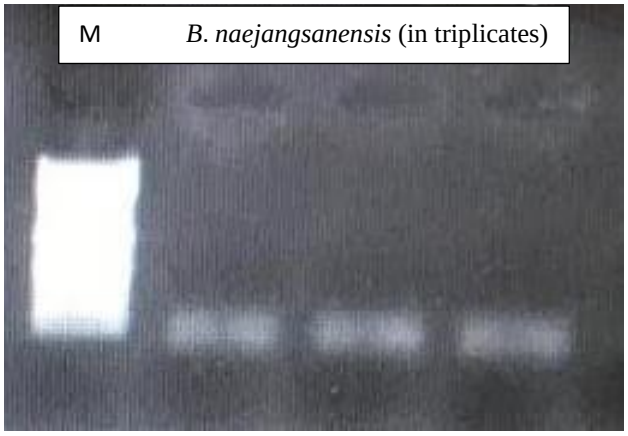

Figure 1: PCR product confirmation for the 16S rDNA genes of the *B. naejangsanensis* (M= Marker, 1-3=16S rDNA gene) (sample done in triplicate).

2.4 Analytical methods

Through the HPLC 1100 series, he worked on carrying out analytical processes for by Agilent® Technologies USA. By initially drawing samples daily from the first day to the fifth day of the decomposition experiment, the HPLC data indicated OTA and the data for the derived ochratoxin α (OT-α). He suspended the bacterial granules in 1 ml of methanol and applied a speed of central pressure (4 × g for 20 minutes). Minutes at 4 degrees Celsius) and to conduct the process of analyzing the supernatant. (EN) and (ISO) protocols were applied for the cleaning process of the immunoaffinity columns, obtaining the derivatization, and the initial LC separation process with the detection of the fluorescence of the compounds. This was implemented through 3 copy operations**.**

2.5 Susceptibility testing of B. naejangsanensis against antibiotics

He worked through the agar dilution technique to determine the minimum inhibitory concentration (MIC) of antibiotics, which is an accurate and common method to evaluate the effectiveness of antibiotics against certain types of bacteria, according to the study conducted (Krochmal & Wicher, 2021). This study prepared agar plates containing concentrations of different types of antibiotics in order to measure their effect on bacterial growth on the day of the experiment. Tubes containing different doses of antibiotics were prepared by placing these doses on plates containing 20 ml of Diagnostic Sensitivity Test Agar - DST) which was obtained from Hi Media, Bombay, India. The concentrations of antibiotics used ranged from 2 to 1024 micrograms per ml. This study shows that these concentrations cover a wide range that allows determining the ability of antibiotics to inhibit bacterial growth at different levels. After preparing the plates, the injection of 22 small drops, which contain between 10^4 to 10^5 bacterial cells from cultures that were in the exponential growth stage in the plates, these cultures represent bacteria that are in the strongest stages of growth, which makes them suitable for testing the effect of antibiotics. After injecting the cultures, the plates were left to dry for an hour at a temperature of 37 °C to ensure that the samples were stabilized before starting the incubation process. To confirm the results of the experiment and ensure their accuracy, control plates free of antibiotics were prepared, where the same bacterial species were grown to compare the growth of bacteria in the absence of antibiotics and these plates provided a reference that allowed determining the effect of antibiotics on bacterial growth. The plates were placed in an incubator at a temperature of 30 degrees Celsius for 24 hours, and after the incubation period had passed, the results were evaluated by observing the growth of bacteria on the plates.

2.6 Statistical analysis

It provides the average of three separate measurements in this investigation. An analysis was done on the outcomes of a one-way analysis of variance (ANOVA).

III. RESULTS

Growth curve of the Brevundimonas naejangsanensis

The data showed that by the growth curve of *B. naejangsanensis*. This type of strain cultured in LB medium free of OTA at 28 °C is shown in Figure 3.

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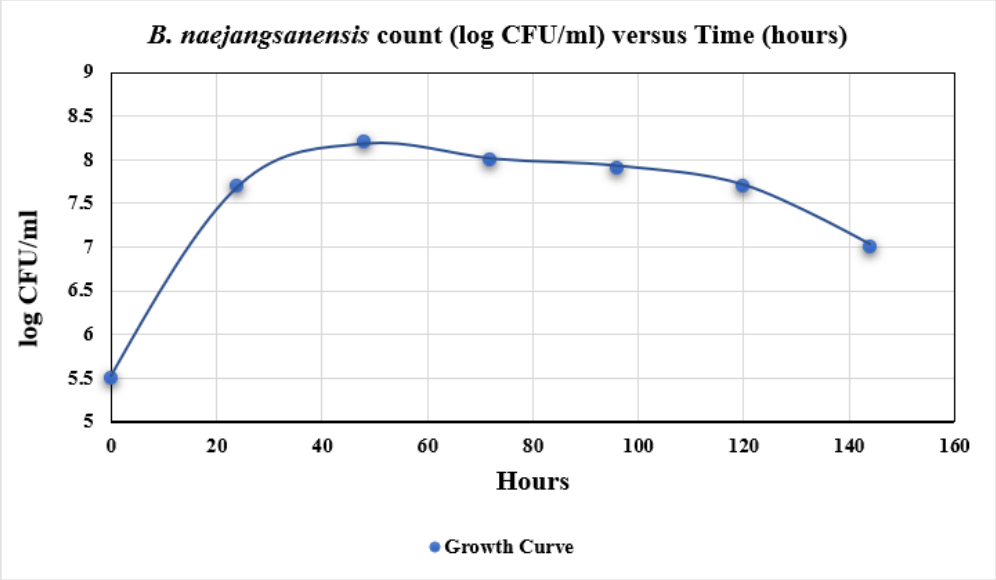

Figure 3: The biodegradation of OTA by *Brevundimonas naejangsanensis*

During the biodegradation experiment *Brevundimonas naejangsanensis* degraded the original amount of OTA by 60 % on the first day, 85% on the second day, and 99-100 % at the end of the third day, the concentration was measured by HPLC. OTA concentration in the cell free control remained 4 and 10 mg/l during the incubation (3-5 days) as was measured by HPLC. Pellets were also measured; OTA concentration was negligible (under 0.2%). Based on the results OTA was metabolized to OTα since OTα content increased in parallel by OTA decrease (Figure 4). Measurements were carried out in triplicates, SD>3%.

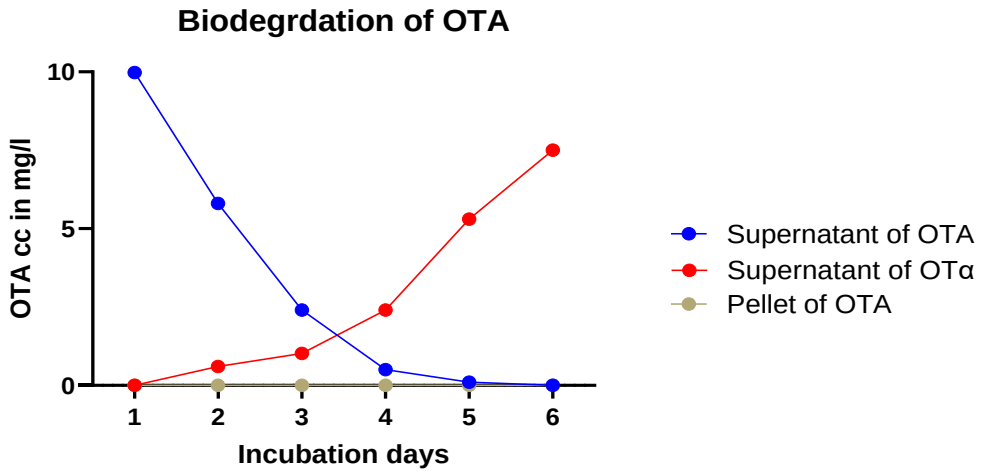

Fig 4: Biodegradation of OTA by *Brevundimonas naejangsanensis* during 3-5 days experiment

The ability of B. naejangsanensis to degrade two concentrations of OTA

B. naejangsanensis being able to completely break down OTA in the culture medium (LB) demonstrated the strong biodegradation capacity of this strain of B. Naejangsanensis. When OTA was cultivated in OTA-LB for multiple times, at various temperatures, inoculum sizes, and concentrations, it was almost completely eliminated (up to 100%). OTA conversion rate was increased from 01 to 1% inoculum size. A lower lag time was seen in testing with larger inocula. It's likely that bacteria developed rapidly, started biodegrading ochratoxin A, and transformed ochratoxin A into ochratoxin in its entirety. Cells rapidly adjusted to the OTA-LB treatment and started generating the enzymes needed to degrade the toxin. The pace at which ochratoxin A degrades varies with inoculum size, taking between 24 and 48 hours. After 24 and 72 hours, respectively, a 60%, 85% and almost 100% at the end of day five rise was observed when the inoculum size was increased

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from 01 to 1%. When a concentrated inoculum was used, 50% of the ochratoxin A was broken down in a period of 24 hours. The potential of B. Naejangsanensis to degrade OTA at 4 ppm concentration was significantly reduced over a five-day period. Findings from this study showed that B. Naejangsanensis converted 4 and 10 ppm of OTA to OTα (Figure 4 & 5). OTA decreased on average by approximately 85% (RSD: 12%) after three days at 24°C and by 99% (RDS: 1%) ($P < 0.05$) after five days at 28 °C in comparison to the control (100% OTA). The results of our investigations, which were carried out from 22 to 28°C, indicated that the bacterial degrading activity was marginally more effective at 28°C ($P < 0.05$). After 24 hours of incubation, the degrading activity was operational. The outcomes demonstrated that OTA may be changed into OT by enzymes produced by A. Calcoaceticus. As expected, based on the OTA's chemical structure, microbial degradation of OTA produces OT and L-phenylalanine by amide bond hydrolysis. The metabolite generated by OT was identified using HPLC-HRMS.

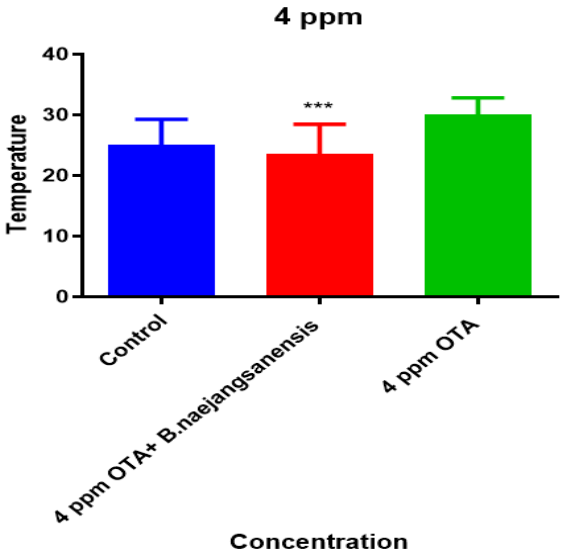

Figure 5. Changes of OTA concentration and viable B. Naejangsanensis in LB medium with ochratoxin A. Concentration of 4 ppm at 28 °C.

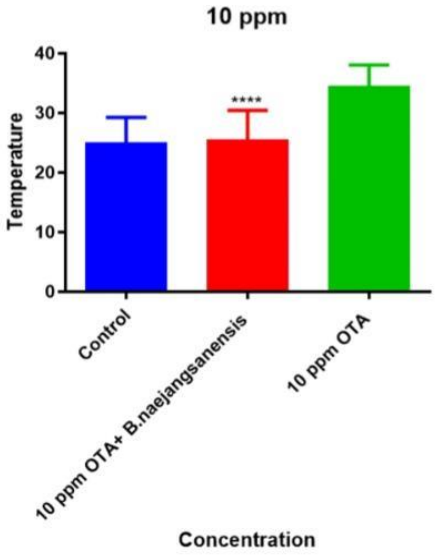

Figure 6: Changes of OTA concentration and viable B. Naejangsanensis in LB medium with ochratoxin A. Concentration of 10 ppm at 28°C.

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***Brevundimonas naejangsanensis* antibiotic resistance ability**

According to the results, *Brevundimonas naejangsanensis* bacteria showed clear resistance to all beta-lactam antibiotics except cefotaxime, to which it was resistant by 29% and 62% in all different tests and showed strong resistance to most antibiotics from the aminoglycoside class with the exception of neomycin, which had a clear effect on these bacteria the more toxic antibiotics such as rifampicin and nalidixic acid showed an inhibitory effect on the growth of *Brevundimonas naejangsanensis*, even when using low concentrations.

These results lead us to the conclusion that *Brevundimonas naejangsanensis* bacteria are among the most resistant species to antibiotics and This can be explained by the fact that resistance has been shown to a large number of antibiotics, amounting to 13 out of 18 antibiotics tested, as this behavior is an indicator of the ability of these bacteria to adapt to difficult environments, which enhances Its ability to survive and spread under environmental conditions that include significant exposure to antibiotics and also been noted that this strain possesses multiple resistance, which means that it can show resistance against several classes of antibiotics at the same time. This type of multiple resistance represents a major challenge to traditional treatments, which may require and this searching for new alternatives or different therapeutic strategies to combat these bacteria.

IV. DISCUSSION

The rapid increase in the spread of agricultural crop diseases represents a prominent issue threatening food safety because of its direct link to the emergence of mycotoxins, including ochratoxin A (OTA) (Moretti et al., 2018), as mycotoxins are considered one of the most serious health issues related to food in crops. Agricultural diseases, as their spread in fields poses a major threat to public health, and contamination may occur indirectly through the consumption of food products of animal origin, as these animals may have eaten feed contaminated with mycotoxins (Capriotti et al., 2012).

One of the most promising ways to deal with this problem is to biodegrade and detoxify mycotoxins using microorganisms and research shows that some microbes have a natural ability to break down mycotoxins and convert them into harmless compounds and This approach is considered one of the most effective solutions, due to the ability of these organisms to degrade some of the most dangerous mycotoxins including ochratoxin A. Although the number of products available on the market based on this approach is still limited (e.g. FumEnzym and MycoFix) the technical difficulties associated Improving these products stands as an obstacle to the development of more effective commercial solutions. Among the currently available products, either the living microbe or the enzyme extracted from it takes a prominent role in the process of getting rid of mycotoxins, as these organisms or their enzymes analyze toxic compounds and transform them into harmless substances, and this contributes to reducing the effect of toxins on health. It should be noted that there is a difference between the processes of biodegradation and detoxification and explained for several reasons, as biodegradation may not always mean complete elimination of toxins. In other words, the mycotoxin may be partially broken down, but it still retains a degree of toxicity, so it cannot be considered Biodegradation alone is not a final solution unless it is certain that the toxin has been completely eliminated from its harmful effects and use of microorganisms in the process of biodegradation of ochratoxin requires in-depth research to find more efficient and safe methods to ensure complete elimination of toxins and the development of innovative products that can be applied to Wide scope in agriculture and animal feed to ensure crop safety and reduce risks associated with food poisoning.

To date, according to what is reported in the scientific literature, among the 10 known species of bacteria capable of biologically degrading ochratoxin A (OTA). He only tested two of them in a practical way via biotest. The first was Cupriavidus basilensis, which was carried out by Ferenczi and his colleagues (2024). In the case of *Lactobacillus acidophilus* **, Researchers tested MCN with encouraging results (Fuchs et al., 2008). process of testing the ability of bacteria to enzymes associated with it, the biological decomposition of toxins is a crucial step before adopting their use in practical applications. Within this study, he worked on analyzing the ability of B. naejangsanensis to degrade OTA at very low and high concentrations (4 and 10 mg/L) over a period of five days, as it was shown that results showed great effectiveness in decomposing toxins, with values ranging between 99% and 100%. He worked on discovering the main product resulting from the decomposition, which is ochratoxin α. product is consistent with several results in other studies, where species of *Lactobacillus* showed a moderate ability to degrade ochratoxin A despite Although the resulting degradation products and their potential toxic effects have not been investigated, other studies have had more positive data with some Lactobacillus species. In a study by Fuchs and colleagues (2008), approximately 97% of OTA was degraded after four hours of incubation with *Lactobacillus acidophilus* and strains of *L. rhamnosus* CECT 278T and *L. plantarum* CECT 749 were able to degrade OTA to values ranging between 97% and 95%, and the products resulting from the degradation were OTA-α and phenylalanine (Phe) (Luz et al., 2018). The study by Piotrowska and Zakowsk, 2005) *Acinetobacter calcoaceticus* is capable of degrading OTA, although the resulting degradation products have not been identified in this case. Similarly, Stander and colleagues (2000) also discovered the presence of an enzyme responsible for ochratoxin degradation in a strain of *Aspergillus niger*, where the analysis showed the presence of the degradation products OTA-α and phenyl. Alanine As demonstrated by

a study by Chang and colleagues (2015) *Bacillus amyloliquefaciens* ASAG1 was able to completely hydrolyze OTA after one day of incubation.

100% degradation of ochratoxin A by the *Cupriavidus basilensis* strain ŐR16 (Ferenczi et al., 2014) and also by the genus *Cupriavidus* (Al-Nussairawi et al., 2020) was reported in another study by Al-Nussairawi and colleagues (2023), which showed the results showed that *Acinetobacter calcoaceticus* was able to effectively degrade OTA and this strain was isolated from the soil. This amount of studies indicates that biodegradation of OTA toxins by microorganisms is one of the promising solutions that can contribute significantly to reducing the risk of mycotoxins, especially in chains. Food and animal food. The success of the biodegradation process depends mainly on the ability of the organism to break down the toxin into less harmful or harmless components, a process that requires precise identification of the byproducts generated by decomposition, to ensure that no negative effects on public health occur.

Although a number of microorganisms have shown promising results in OTA degradation, more research is urgently needed to ensure that these processes are improved and applied on a broader scale Many factors, such as environmental conditions, type of microbial strain, and toxin concentration, play an important role in the success of these operations. Therefore, it can be said that the development of microorganism-based techniques for toxin biodegradation constitutes a promising future in addressing mycotoxin contamination and achieving food safety and by continuing to search for new organisms or improving existing strains, the ability of this biological approach to provide effective and applicable solutions in the agricultural and food industry can be enhanced and understanding the details of the chemical processes that occur during the biological degradation of toxins can help develop more advanced and safer technologies for application on a commercial scale.

V. RECOMMENDATION

The aforementioned investigation indicates that *B. naejangsanensis* can degrade OTA in LB medium at 28 and 30°C with an initial OTA level of 4 and 10 ppm. OTA was found to be the product of *B. naejangsanensis's* degradation of OTα, according to TLC testing; nevertheless, further experimental confirmation is required. OTA has been shown to be far less dangerous than originally believed. Because of this, some have suggested that the OTA degradation capacity of *B. naejangsanensis* represents an OTA microbiological detoxication. An in vitro testing system was used in this investigation, and environmental parameters were observed. Though promising, these results do not demonstrate that food or feed can break down OTA in an in-situ system. However, the enzymatic potential of *B. naejangsanensis* could be a promising approach for OTA biodegradation and detoxification in food, and feed products.

VI. CONCLUSION

Ochratoxins are considered to be one of the most important mycotoxins in terms of commercial value because agricultural products are at risk of contamination by ochratoxin-producing fungi at various stages, such as before or during harvest. After that it can be within the supply phase so its presence in contaminated food or feed poses a great risk to human and animal health Based on laws related to health and safety ochratoxin levels should not be exceeded to avoid harmful effects of this poison and harmful effects of this poison To be protected, permissible limits on agricultural products used for human or animal consumption have been set within the supply chain of pulses, potatoes and many other commodities were emphasized ochratoxins can be reduced, preventing them completely is a challenge. Therefore, it is increasingly important to find effective ways to clean contaminated products. And regarding detoxification systems, they have been worked on through treatments to get rid of mycotoxins when contaminated agricultural products are turned into animal feed and some treatments have proven effective in reducing mycotoxin levels will apply to all types of poisons from to a comprehensive approach. As for ochratoxins (OTA), one of the most promising approaches is to eliminate contamination using microorganisms or enzymes produced by them Furthermore, preventing ochratoxin contamination from cultivation to storage and distribution is a top priority, e.g Growth rates of ochratoxin-producing fungi managing humidity and temperature during storage thus it becomes necessary to apply these preventive measures alongside effective detoxification treatments to ensure food and feed safety be the ideal solution for detoxification safely and effectively.

Thanks, appreciation and gratitude

I would like to thank everyone who helped me to complete the work

Conflict of interest

I would like to declare that there are no problems or conflicts of interest

Authors' scientific contribution

All works included in this article were designed and produced by Dr. Mohammed Al-Nussairawi and he approved their publication**.**

Finance

At personal expense

Data availability

Within the manuscript are all datasets that have been created or analyzed and are embedded within it

Statement of ethics

This article does not include any experiments or studies performed on human participants or animals

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