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Research Article

Effectiveness of *Triticum Vulgare* and Nitrofurazone Combination in Secondary Infections Associated with Myiasis Wounds in Dogs

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ABSTRACT

Myiasis wounds have become increasingly common in recent years, posing challenges due to variable prognoses and Myiasis wounds have become increasingly common in recent years, posing challenges due to variable prognoses and complex treatments. This study evaluated the efficacy of the *Triticum vulgare* and Nitrofurazone combination for secondary infections caused by myiasis in dogs. Forty-two medium and large-breed dogs with myiasis wounds, aged 2 months to 5 years and weighing 5 to 56 kg, were included. Following the manual removal of larvae, a pomade comprised of 50 mg/g *Triticum vulgare* extract and 0.2 g Nitrofurazone was administered three times daily. Wound assessments were performed weekly for four weeks, including surface area measurements and contraction reeks. The most common wounds due to myiasis occur in Mongrels (47.6%) and Kangals (33.3%). Myiasis primarily affects the extremities (48%) and the genital area (28%), mainly occurring (66%) during the summer. The mean wound area significantly reduced, from 10.0 ± 2.5 cm^2 to 1.5 ± 0.8 cm^2 by week four, with an 85% wound contraction and healing rate. This study concludes that a combination of *Triticum vulgare* and Nitrofurazone is highly effective in managing secondary infections resulting from myiasis wounds in dogs.

Keywords: Myiasis, Nitrofurazone, *Triticum vulgare*, Wound

INTRODUCTION

Myiasis is caused by the larvae or eggs laid by flies on open wounds, skin ulcers, or other parts of the body in animals (1, 2). These infections can lead to severe wounds and general health disorders, causing significant health and economic problems (3). The World Health Organization lists myiasis as one of the major animal diseases in the Global Early Warning System (4). Although its prevalence is reported to be 37.4%, the infection rate can reach 100% in regions with high fly density or poor hygiene conditions (5). Cases of myiasis are primarily observed in cattle (46.4%), followed by dogs (15.3%), pigs (6%), horses (4%), and sheep (1%) (6). In these infections, the mechanical removal of the larvae and effective treatment usually provide favorable results (3). However, myiasis infections may result in death if an appropriate treatment protocol is not applied (3, 7, 8).

In veterinary medicine, there is a lack of sufficient data on the efficacy of wound treatment preparations for managing myiasis wound infections. In the relevant literature, the effectiveness of antiseptics such as creolin and sprays containing larvicidal pietrin, ivermectin derivative compounds, and insect growth regulators (IGR) has been reported in the treatment of myiasis wound infections (8). However, reports indicate that creolin is highly toxic to living tissues. Additionally, topical larvicidal products and other chemicals, while effective in killing larvae in treated wounds, delay the healing process (3, 9). These applications, the effectiveness of which has been reported in the literature, are currently of limited use. More research is needed to ensure that veterinarians are knowledgeable about the treatment of myiasis and to better understand the effectiveness of current applications used in the wound treatment of these lesions (7, 9).

Nitrofurazone is inexpensive, has a low risk of reaction compared to other drugs, and is frequently used to treat open wounds (10, 11). It has been reported that nitrofurazone does not cause maceration in tissues when applied locally and does not cause pain during application (12). *Triticum vulgare* is a cicatrizant agent that can be safely used with antibacterial drugs in wound treatments (13). When applied locally to the wound area, it induces the proliferation of fibroblasts and endothelial cells, accelerates repair, and promotes rapid healing and wound closure (14, 15, 16, 17). Several studies have examined the effects of these agents on wound healing. These studies have focused on healing wounds observed in human patients and those experimentally induced in rats or rabbits (13, 14, 18, 19, 20). Furthermore, biomedical studies have reported that these agents may be safely combined with different substances or used in various formulations (13, 18, 19, 21). However, there is limited literature in veterinary medicine regarding the efficacy

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of these agents in healing various wounds in other species.

Increasing temperatures due to global warming accelerate the life cycles of flies and boost their populations, which bears the potential for an increase in myiasis cases from year to year (22). Considering the effects of *Triticum vulgare* and Nitrofurazone reported in the literature, it is believed that these two agents may have significant effects on wound healing when combined. In this regard, the aim was to evaluate the efficacy of the combination of *Triticum vulgare*, a cicatricial agent used in open wound treatment, and the topical antibacterial Nitrofurazone in clinical practice for myiasis wound infections encountered in dogs, considering the deficiencies in the existing literature.

MATERIAL AND METHODS

Study group

The study included 42 dogs of varying breeds, ages, and genders admitted to the Surgery Clinic of Harran University Faculty of Veterinary Medicine Animal Hospital during the spring and summer months of 2023–2024, presenting with maggot-infested wounds of differing diameters across various body regions. Data on breed, age, sex, body weight, and the anatomical location of myiasis were systematically recorded. To standardize the cohort, only dogs aged 2–5 years were enrolled in the final analysis.

The study protocol was approved by the Local Ethics Committee on Animal Experiments, Harran University (Decision number: 2024 /008 /02).

Treatment procedure

Clinical and laboratory examinations were conducted on dogs that presented for treatment. Cardiopulmonary values and body temperature were measured during the clinical examination using a Mindray UMEC12VET bedside monitor (Shenzhen Mindray Bio-Medical Electronics Co, Shenzhen, China). Blood samples (2.5 ml) were obtained from the vena cephalica antebrachii for laboratory examination (23). The results of hematologic (WBC, RBC) (CFE 279, Hematology Analyzer, France) and biochemical (AST, ALT, CREA, BUN) (Arkray Inc., Kyoto, Japan) analyses were evaluated. Dogs whose clinical examination results were within the reference range and did not require additional drug treatment were included in the study. As part of the treatment protocol, wounds with myiasis were first cleaned with physiological saline (NaCl 0.9%, Polifarma, Turkey) without using any anesthetic. All visible larvae in the wound area were manually removed with the help of sterile forceps. Surgical debridement was performed in cases where necrotic tissue had developed in the wound area (3). After the larvae were removed, treatment continued with cleaning the area using a 10% povidone-iodine solution (Batiqonix Biyosidal, Turkey) diluted at 1:10 with physiological saline (NaCl 0.9%) (24). For the wound care, pet owners were provided with Fito cream® (50 mg/g, Tripharma, Istanbul), which contains *Triticum vulgare* extract, and Furacin® ointment (Sanofi, Istanbul), which comprises 2% Nitrofurazone. These two products were mixed in equal proportions to ensure complete coverage of the wound site with adequate quantities sufficient for a duration of four weeks use. Patients were informed of the need to apply this mixture three times daily to support complete wound closure (10). While bandaging was applied to the wounds after the initial application, the pet owners did not continue it. Furthermore, a single dose (0.4 mg/kg) of subcutaneous Moxidectin 1% (Cydectin®, Pfizer, New York, USA) was administered to the dogs on the first day as an antiparasitic (25). An Elizabethan collar was applied during the treatment to prevent the patient from licking the wound area. No systemic antibiotics were given to the dogs in this study, and all wounds were examined weekly. The borders of the wound area were carefully drawn on clean, transparent paper with a 0.3 mm-tipped drawing pen on day 0 and during weeks 1, 2, 3, and 4. These drawings were transferred to acetate paper marked with millimetric lines to measure the wound area in millimeters. CorelDRAW X5 and Golden Software Didger 3 were used to calculate the wound areas. The drawings on the acetate paper were transferred to the computer environment at a 1:1 scale using a scanner and saved as JPG format. Each wound area was drawn as a closed curve in the CorelDRAW X5 program and saved in the DXF file format. These files were opened using Didger 3 software for geological digitization, and the area of each closed curve was calculated in cm^2 (12, 26). The same investigator conducted all the procedures to ensure uniformity. The wound area and contraction rate were calculated from these measurements. (26, 27).

Statistical analysis

The initial wound dimensions and the time to complete wound closure were calculated as mean ± standard deviation (mean ± SD) in cm^2. The wound area (WA) and wound reduction (WC) following topical application were expressed as percentages (%). The wound surface areas (cm^2) of wounds treated with Nitrofurazone and *Triticum vulgare* were analyzed using the Kruskal-Wallis test and compared by week. The effect of topical application on the wound area (WA) percentage and wound shrinkage (WC) percentage was analyzed with the Kruskal-Wallis and the Mann-Whitney U test for intergroup comparisons. All statistical analyses were performed using SPSS 22.1 (IBM Corporation, Armonk, NY, USA), and the significance level was established at $p < 0.05$.

RESULTS

The average age of the dogs included in the study was 19 ± 11 months, and their body weights ranged from 5 to 56 kg. The clinical and laboratory examination results for the dogs are presented in Tables 1 and 2. Forty-two dogs (36 males and six females) were identified at ages of 24 ± 14 months (for males) and 11 ± 7 months (for females) respectively. Upon examining the breed distribution records of the dogs in the study, it was observed that the majority of the cases were mixed-breed dogs (20), followed by Kangal (14), German Shepherd Dog (2), Belgian Malinois (2), Pomeranian (2), and Rottweiler (2). Regarding the localization and frequency of myiasis cases, 20 (48%) cases occurred in the extremities, 8 (19%) in the head and neck region, 2 (5%) in the abdomen, and 12 (28%) in the genital region (Figure 1). In terms of seasonal distribution, myiasis cases were recorded in all seasons; however, the highest number of cases occurred in the summer (66%) (Figure 2).

Treatment findings

Wound areas of all animals were debrided, and *Triticum vulgare* and Nitrofurazone were applied equally. A single subcutaneous dose of Moxidectin (0.4 mg/kg) was administered to dogs (25). During the treatment period, the pet owners came regularly for clinical controls every week, and four weeks of the control process were completed (Figure 3). It was confirmed that the treatment applications were conducted by each patient owner who brought the control. The animal owners were informed that no maggots had been observed in the wound area after the first intervention. During the control period, no general condition disorders were detected in any of the animals, and no larvae were found in the wound areas. No exudate or signs of inflammation were detected in the lesions of the dogs brought in for control one week after the start of treatment (Figure 4). After the first week, prominent granulation tissue was observed in dogs with wound sizes of approximately 5 cm^2 or less, while re-epithelialization (proliferative phase) became evident in the second week (Figure 5). Granulation tissue began to form during the first week in

Table 1. Some haematological and biochemical parameters of the dogs included in the study (mean ± SD).

Parameter	WBC (x103/µL)	RBC (x106/µL)	AST (U/L)	ALT (U/L)	CREA (mg/dL)	BUN (mg/dL)
Value	13.6±7.5	6.74±1.8	14.1±2.2	59.5±41.2	0.90±0.26	17.6±2.1

WBC: White blood cell, RBC: Red blood cell, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, CREA: Creatinine, BUN: Blood urea nitrogen

Table 2. Some clinical examination results for the dogs included in the study (mean ± SD).

Parameter	WBC (x103/µL)	RBC (x106/µL)	AST (U/L)	ALT (U/L)	CREA (mg/dL)	BUN (mg/dL)
Value	13.6±7.5	6.74±1.8	14.1±2.2	59.5±41.2	0.90±0.26	17.6±2.1

HR: Heart rate, T: Temperature, RR: Respiratory rate, SpO2: Oxygen saturation

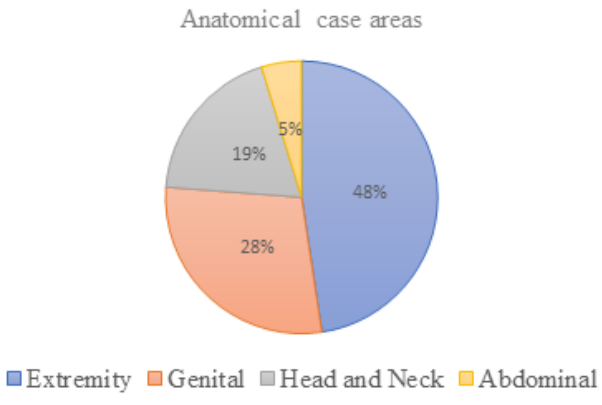

Figure 1: Anatomical distribution of myiasis wounds in dogs by region

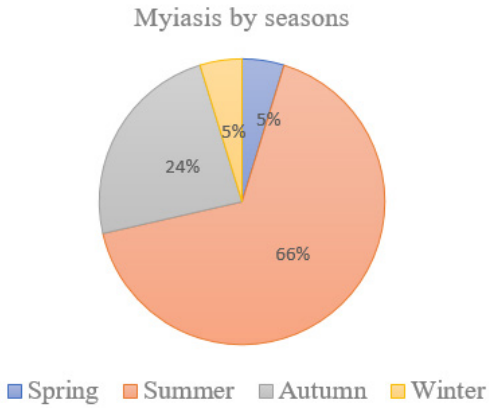

Figure 2: Seasonal distribution of myiasis wounds in dogs

Figure 3: A. Wound myiasis area in the neck of a Rottweiler dog at the 1st week control, B. 2nd week wound area of the same dog, C. 4th week wound area of the same dog (white arrow) (Case 2).

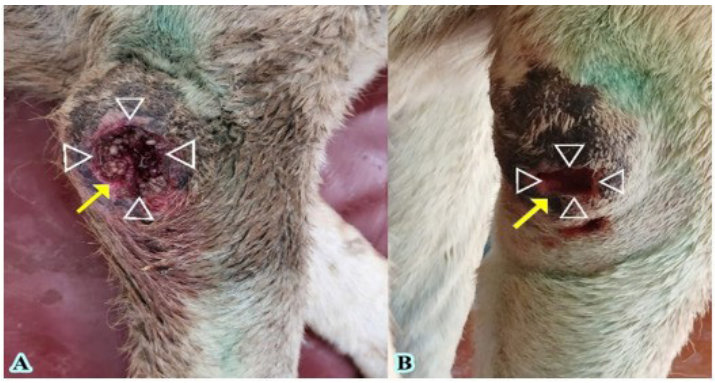

Figure 4: A. Myiasis of a wound in the extremity of a mongrel dog. B. Wound area (white arrowhead) during the first week follow-up of the same case (Case 15).

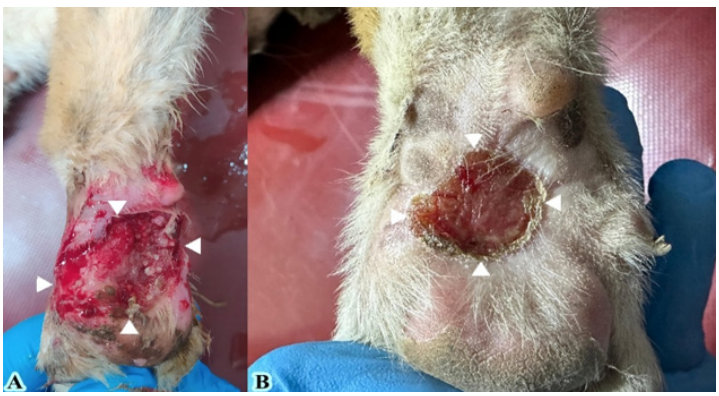

Figure 5: A. Wound myiasis in the extremity of a mongrel dog. B. Wound area (white arrowhead) at the 2nd week follow-up of the same case. (Case 40).

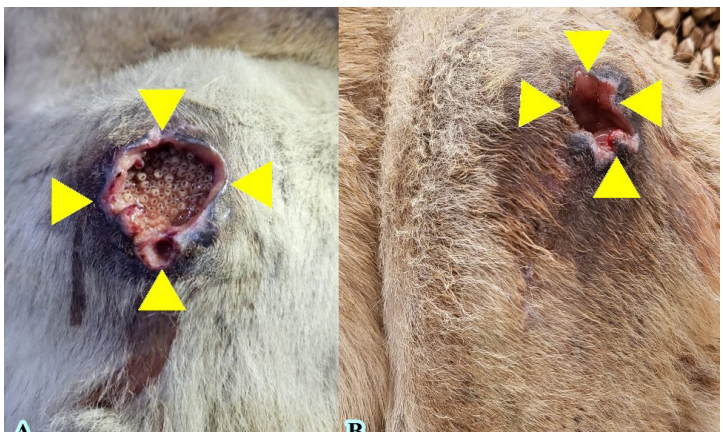

Figure 6: A. Wound myiasis in the extremity of a Kangal dog, B. Wound area of the same case during the 1st week (yellow arrow-head) (Case 41).

dogs with larger wounds (Figure 6). All treated wounds healed without re-infestation of larvae since the start of treatment, and no complications, such as fistula or purulent discharge, were observed. No overall reduction in the wound surface area was noted until complete re-epithelialization occurred. The fastest healing was observed in the first week, while the slowest was noted in the fourth week, depending on the wound surface area. The mean wound surface size was 10.0 ± 2.5 cm². The wound surface areas at the first (1), second (2), third (3), and fourth (4) weeks following topical application were 7.5 ± 2.0 cm², 5.0 ± 1.8 cm², 3.0 ± 1.5 cm², and 1.5 ± 0.8 cm² respectively. While the wound area was determined to be 100% in the first instance, it was statistically significant that this area decreased to 15% in the fourth week, demonstrating a shrinkage rate of 85%. The wound measurements and contraction rates are presented in Tables 3 and 4 respectively.

Table 3. Effect of topical application on changes in wound size (mean ± SD).

Week	0	1	2	3	4	P
Wound surface area (cm2)	10.0 ± 2.5	7.5 ± 2.0	5.0 ± 1.8	3.0 ± 1.5	1.5 ± 0.8	0.012

0: initial, 1: first week, 2: second week, 3: third week, 4: fourth week

Table 4. The effect of topical application on wound area (WA) and wound contraction rate (WC).

Week	0	1	2	3	4	P
WA (%)	100	75	50	30	15	0.045
WC (%)	0	25	50	70	85	0.02
p	0.001	0.041	0.063	0.011	0.034	

0: initial, 1: first week, 2: second week, 3: third week, 4: fourth week.

DISCUSSION

Myiasis wounds are frequently encountered in dogs and heal with the completion of biological processes such as inflammation, cell migration, collagen accumulation, angiogenesis, and re-epithelialization, as with other wound types (3, 27). Although the efficacy of various herbal and chemical drugs contributing to the acceleration of these biological processes in different types of wounds has been reported, information regarding the treatment of myiasis wounds is insufficient (15, 28, 29). Within the scope of this study, when examined at the clinical level using a combination of Triticum vulgare and Nitrofurazone after the removal of larvae in the treatment of myiasis wounds in dogs, near-complete wound closure was achieved in 42 cases, including deep and extensive wounds, within 4 weeks, and successful results were obtained.

In the relevant literature, myiasis cases were mostly observed in the summer months (22, 30). In the present study, most cases were noted in the summer months due to the increase in the fly population with rising temperatures in Şanlıurfa Province. This indicates that myiasis cases may be more common in provinces with hot climates and that fly control should be managed more meticulously in these regions.

Studies on myiasis wounds in animals found that these wounds resulted from traumatic injuries, particularly in large-breed male dogs (22, 30). Specifically, Johnson et al. reported that 24 of 29 dogs (82.8%) in their study were large-breed male mongrel dogs, followed by breeds such as Boerboel and Rottweiler (31). In the present study, myiasis wounds were primarily encountered in male mongrel dogs, followed by Kangal dogs. The hormonal nature of male dogs may lead them to exhibit more aggressive and active behaviors than female dogs, which can result in injuries. It could also be argued that keeping small-breed dogs in a home environment, unlike large-breed dogs, may reduce the risk of such injuries. In addition, the high incidence of myiasis wounds in Kangal dogs is attributed to the adaptation of these dogs to our region. Another study on myiasis wounds in dogs reported the anatomical area of the body where more wounds were observed. In a study conducted by Orfanou et al., it was reported that myiasis wounds were observed in the abdominal region at a rate of 44.8% and in the extremities at a rate of 6.9% (25), while another study reported that they were observed in the extremities at a rate of 44.4% (31). The findings obtained in this study showed that the most common lesion in dogs was observed in the extremities, with a rate of 49%. This difference can be attributed to variations in the environmental factors to which dogs are exposed and their interactions with others dogs. Ectoparasitic applications are recommended as supportive treatments for myiasis wounds (9).

In a study examining the efficacy of ectoparasitic applications alongside the treatment of myiasis wounds in dogs, lotilaner, which belongs to the chemical class of isoxazoline, demonstrated effectiveness rates of 80.5%, 93%, and 100% for larval expulsion in myiasis cases at 2, 6, and 24 hours after oral administration, respectively (32). In another study, sarolaner was administered orally, and all larvae died (33). In addition to ectoparasitic applications, systemic antibiotic and anti-inflammatory treatments were applied in these two studies, yielding effective results obtained. The difference of the present study is that, in addition to tropical Triticum vulgare and Nitrofurazone, subcutaneous moxidectin (0.4 mg/kg) was also used as an ectoparasitic application, and favorable results were obtained in all cases. According to the information obtained from the patient owners and weekly controls, no larvae were found in the wounds cleaned of larvae after topical application. In this respect, ectoparasitic applications should be performed for the treatment of wounds with myiasis.

Studies on *Triticum Vulgare* (wheat extract) and Nitrofurazone are currently available, having been primarily investigated in various wounds affecting humans, as well as in experimental models using rats or rabbits (13, 14, 18, 19, 20, 34). The present study examined the effects of Triticum Vulgare (wheat extract) and Nitrofurazone on wounds caused by myiasis in dogs. It revealed important results at the clinical level, noting that these agents positively affect the acceleration of wound healing. These findings align with the results of several studies that support wound healing

by these two agents. In studies conducted by Souza et al. and Silva et al., *Triticum Vulgare* accelerated wound healing and promoted the re-epithelialization process (35, 36). These studies suggest that *Triticum Vulgare* promotes rapid healing of the wound area and may play a significant role in restoring tissue integrity. Moreover, Bedir et al. reported positive results in wound healing after 21 days when applied in cream form to experimental wound models in diabetic rats (16). In another study, almost complete healing was observed in 50 human patients with diabetic foot ulcers after 29 days (19). Considering these studies, it can be concluded that *Triticum Vulgare* has favorable effects on chronic wounds. In studies conducted with Nitrofurazone, favorable results have been reported, particularly regarding the prevention of bacterial contamination and the elimination of larvae. Lima et al. reported that Nitrofurazone eliminated larvae within three days, and wound healing was completed within four weeks in two patients with oral myiasis. In their studies on experimental wound models in rabbits, Pişkin et al. and Shahzad et al. reported that the combination of Momordica Charantia (bitter gourd) and Nitrofurazone, a herbal product, along with the local application of Jacobaea Maritima (ash flower) and Nitrofurazone, accelerated wound healing (20, 37, 38). Shahzad et al. reported that complete healing with nearly 100% closure was achieved in 24 days (38). These results are consistent with the rapid healing process observed in the present study. Other studies on the accelerating effect of herbal products on the healing process of wounds with myiasis are also noteworthy. In a pioneering study using neem oil and St John's wort oil on 44 domestic animals, including dogs, wounds with myiasis healed within 10 to 32 days (3). Similarly, in the present study, it was observed that the combination of herbal *Triticum Vulgare* and Nitrofurazone had positive effects on wounds with myiasis, which presented a potential worsening prognosis, and the wound healing process was completed within a range of 7-28 days. The clinical significance of our study is that a treatment protocol involving a plant-based agent and an antibacterial agent may provide an alternative to conventional approaches for treating wounds with myiasis. Clinicians may find *Triticum Vulgare* and Nitrofurazone attractive options due to their low side effect profiles and their ability to accelerate wound healing.

CONCLUSION

In conclusion, this study demonstrates the effects of *Triticum Vulgare* and Nitrofurazone combined with ectoparasitic applications on the healing rate of myiasis wounds in dogs. Moreover, myiasis wounds, which are more frequently observed in male dogs and certain breeds, are influenced by environmental and hormonal factors, and this should be taken into consideration regarding both veterinary practice and animal adoption. Thus, clinicians believe that this combination can be used successfully.

DECLARATIONS

Availability of Data and Materials: The data that support the findings of this study are available on request from the corresponding author.

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Ethical Statement: This study was completed in accordance with the procedures and principles of Harran University Animal Experiments Local Ethics Committee (Session Number: 2024/008/02).

Competing Interests: The authors declare that there is no competing of interest regarding the publication of this article.

Declaration of Generative Artificial Intelligence: The authors of the current study declare that the article and/or tables and figures were not written/created by AI and AI-assisted technologies.

Authors' Contributions: All authors contributed to this present work: KY, ÜY, and AH designed the study. KY, KDI, MSK and MSH performed the experiments, KY, KDI, MSK and MSH collected data, KY, ÜY and AH analyzed the data. KY, KDI, MSK and MSH drafted the manuscript. All authors revised the manuscript. All authors read and approved the final manuscript.

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