



The profile of capsaicinoids and pigments as a signal for the ripening and senescence of Capsicum

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ABSTRACT

The relationship between the accumulation of pigments regarding with that of capsaicinoids contents with growth and aging processes of fruits from several *Capsicum* species was examined. The capsaicinoid profile showed a stationary phase of accumulation during the transition from the green to red, yellow or orange final color, characteristic of each species. After the color transition phase, when maturation is reached, the stationary phase was stable for 10-15 days, until the fruits come into senescence, state that can be appreciated by the changes in morphology, mainly loss of turgor and wilting. The last stage of maturation starts with the start of the lowering in the amount of capsaicinoids and the appearing of the transition phase from the green to the final color of the fruit. When the accumulation of pigments reaches its maximum the fruit enters senescence, and the capsaicinoids content decreases to a minimum in all species studied. These results indicate that the capsaicinoids content have a direct metabolic correlation with the elongation of the fruits and inverse to the biosynthesis of pigments. Furthermore, the results from the accumulation profile showed that the end of capsaicinoids accumulation was accompanied with the start of the pigments biosynthesis, suggesting this metabolic switch is the signal for the ripening and senescence processes of *Capsicum* fruits., and supporting the idea that chili fruits are no-climacteric.

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INTRODUCTION

The Capsicum genus (chili pepper) fruits are worldwide used in food and pharmaceutical industry mostly due to its pungent taste, flavor, and pigments (Krishna 2004, Mohd Hassan et al., 2019), and by its pharmacological and nutraceutical properties (Materska and Perucka 2005, Hue and Dong 2010). The pungent taste is due to capsaicinoids (Iwai et al., 1979), and the pigment color, usually yellow, orange, o red, is due to carotenoids (Sing de Ugaz, 1997, Mohd Hassan et al., 2019). Variations of pungent and carotenoid compounds regarding to the growth stage of fruits and have been extensively, but individually examined (Iwai et al., 1979, de Azevedo-Meleiro and Rodriguez-Amaya, 2009, Mohd Hassan et al., 2019). The biosynthetic pathways of have been studied in some detail, however, synchronization and relationship between biosynthesis, degradation and/or turnover of both group of compounds regarding to the stage of maturation have received no attention. It is though that capsaicinoids may be highly involved in other metabolic pathways, such carotenoids, acting as a chemical signal for the fruit's development. In this work, the relationship between the accumulation of these two group of compounds during the growth and ageing processes of several *Capsicum* species was examined.

MATERIALS AND METHODS

Fruits of several species of *Capsicum* and in different stages of maturation were harvested from plants cultivated in greenhouse. Capsaicinoids and phenolic compounds were extracted with ethanol from placental tissue ground in the presence of liquid nitrogen. Pigments and other carotenoids were extracted with acetone from pericarp ground in the presence of liquid nitrogen, followed by liquid-liquid extraction with ethyl ether. The ethereal fraction was dried over anhydrous sodium sulfate, mixed with 10% NaOH in methanol in a 1:1 ratio, neutralized with HCl, and extracted with ethyl ether again. The organic fraction was evaporated to dryness and the remainder was resuspended in absolute ethanol for analysis by HPLC-UV. Analysis of these compounds in the extracts was performed by HPLC-UV or GC-IF, GC-MS.

RESULTS

The pattern of fruit development (elongation and fresh weight changes) for several *Capsicum* species), showed that all cultivars follow the typical sigmoidal growth curve with similar lag (0-8 d), exponential (5-28 d), stationary (40-50 d), and declination (40-50 d) phases regarding to length, weight and placental tissue. Although the maximum growth was variety-specific, all the species presented the shriveling phenomena at the beginning of the declination or senescence phase. Usually, the harvest time for *Capsicum* fruits is accomplished during the last green stage or the transition from green to the pigmented final color, but always before the shriveling stage.

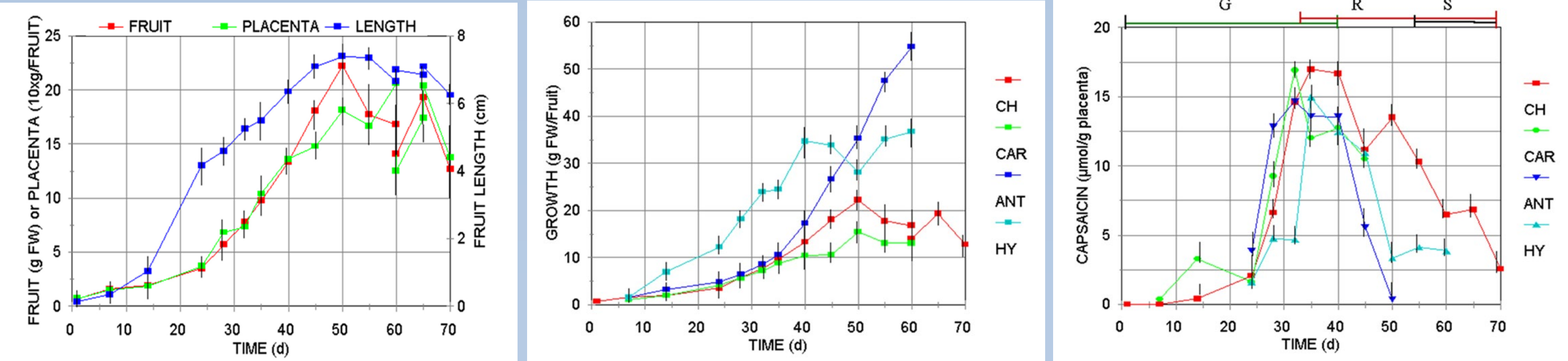


Chart 1. A, Profile of *Capsicum annum* var *annuum* (Jalapeño) fruits development regarding to its fresh wight (FW), growth of its placental tissue (10xmg/Fuit), and its length pattern (cm); B, growth patter of *Capsicum frutescens* (CAR, Carolina Cayenne), three *Capsicum annum* var *annuum* cultivars (CH, Jalapeño chigol; ANT, Antler; HY, Hungarian Yellow), and C, their Capsaicin accumulation pattern regarding the pigments production (color of the superior bars: G, green; R, red, S, senescence shriveling).

The content of capsaicinoids increased in direct relation to the elongation, fresh wight, and growth of the placental tissue, until the green color is exchange by the final carotenoid pigment. Then, accumulation enter to a stationary phase, until fruits turn from the still harvestable mature state (red, orange or yellow), to the shriveling senescence stage. The maximum content of capsaicinoids was observed during the transition stage, from green to the yellow, orange or red pigment.

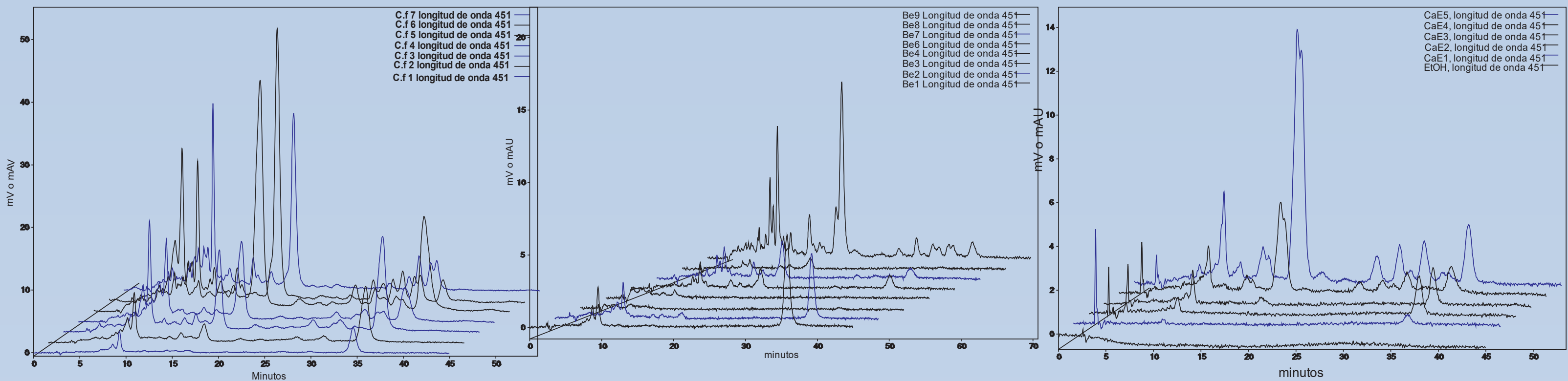


Chart 2. Elution chromatograms of carotenoids in the pericarp of *Capsicum frutescens* var *piquin*, *Capsicum chinense* var *Kahuil* (habanero) and *Capsicum annum* var *Campana* fruits at different stages of ripening.

The chromatographic analysis confirmed that as the content of carotenoids increases, the content of capsaicinoids decrease. Although the declination rate of capsaicinoids was specific for each variety, the content of capsaicinoids and carotenoids showed a clear inverse relationship, observation that deserves further study to determine if chemical signals metabolic relationship between both types of compounds exists. *Capsicum* fruits have been reported to be no-climacteric fruits, therefore declination of capsaicinoids content in postharvest fruits have not been reported.

CONCLUSIONS

Capsaicinoids reached the highest concentration during the color transition, from green to yellow, orange, or red pigment, depending on the variety of *Capsicum*. The end of capsaicinoids accumulation was clearly signaled by the start of the pigment's biosynthesis, suggesting this could be a metabolic switch acting as a signal for the ripening and senescence processes in *Capsicum* fruits, matching also with the reports that chili are no-climacteric fruits. When the accumulation of pigments and other carotenoids reaches its maximum, the fruit enters senescence and the content of capsaicinoids gradually decreases. These results suggest that the content of capsaicinoids could have a direct metabolic relationship with the elongation of the fruits and inversely with the biosynthesis of pigments. Furthermore, as *Capsicum* fruits have been reported to be no-climacteric fruits, declination of capsaicinoids content in postharvest fruits have not been reported.

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COMPARATIVE STUDY OF THE EFFECTS OF ACTIVE INGREDIENT BEESWAX ALCOHOLS AND THEIR PHARMACEUTICAL FORMULATIONS ON ETHANOL-INDUCED GASTRIC ULCER IN RATS

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ABSTRACT

Peptic ulcer is a very common chronic relapsing disease of the gastrointestinal tract, whose main complications (bleeding, perforation, penetration and obstruction) affect the quality of life of patients and can lead to death. The drugs used for its treatment have adverse effects that limit their use. The mixture of alcohols obtained from beeswax, registered in the form of tablets as Abexol®, exerts gastroprotective effects demonstrated in preclinical and clinical studies. The aim of this work was to compare the effects of the active ingredient-beeswax alcohols (BWA) (D-002) and its formulations in form of tablets-BWA and suspension-BWA on ethanol- induced gastric ulcer in rats. The animals were distributed in nine groups: a control without damage and eight groups in which the ulcer was induced by ethanol: a positive control (with damage), one with omeprazole-reference substance- (20 mg/kg), and six treated with D-002, tablets-BWA and suspension-BWA, respectively, at doses of 25 and 200 mg/kg. All treatments significantly reduced the ulcer index with respect to the positive control, although suspension-BWA produced the greatest reduction, without differences being observed between them on the content of mucus, malondialdehyde and total proteins in the gastric mucosa. In conclusion, suspension-BWA exerts an effect superior to that of tablets-BWA and D-002, at the same doses, on gastric ulcer induced by ethanol in rats.

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INTRODUCTION

D-002

Mixture containing six high molecular weight primary aliphatic alcohols, isolated and purified from beeswax

Anti-inflammatory

Antioxidant

Gastroprotector

The 50 mg tablet is registered as a nutritional supplement under the name Abexol® in Cuba and in other countries as a functional food or alternative medicine.



Tablet BWA



Suspension BWA

Objective: to compare the effects of the active ingredient-beeswax alcohols (BWA) (D-002) and its formulations in form of tablets-BWA and suspension-BWA on ethanol- induced gastric ulcer in rats



**Rats Sprague-Dawley
250-300g**

MATERIALS AND METHODS

Time 0

Treatments:

- Vehicle
- D-002
- Tablet Abexol
- Suspension
- Omeprazole

* Oral administration

1 hour

Ethanol 60%

*Oral administration

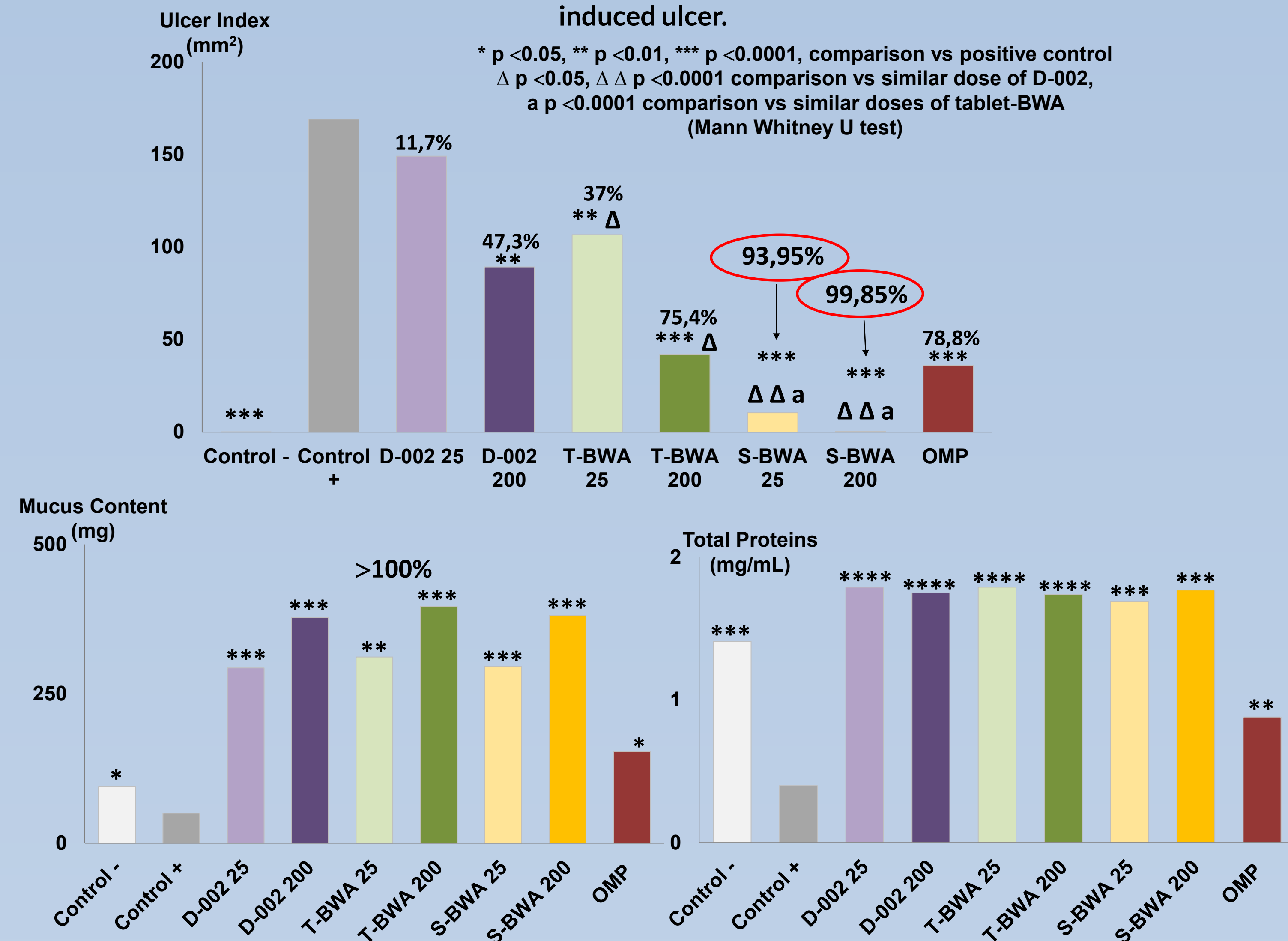
2 hours

Sacrifice

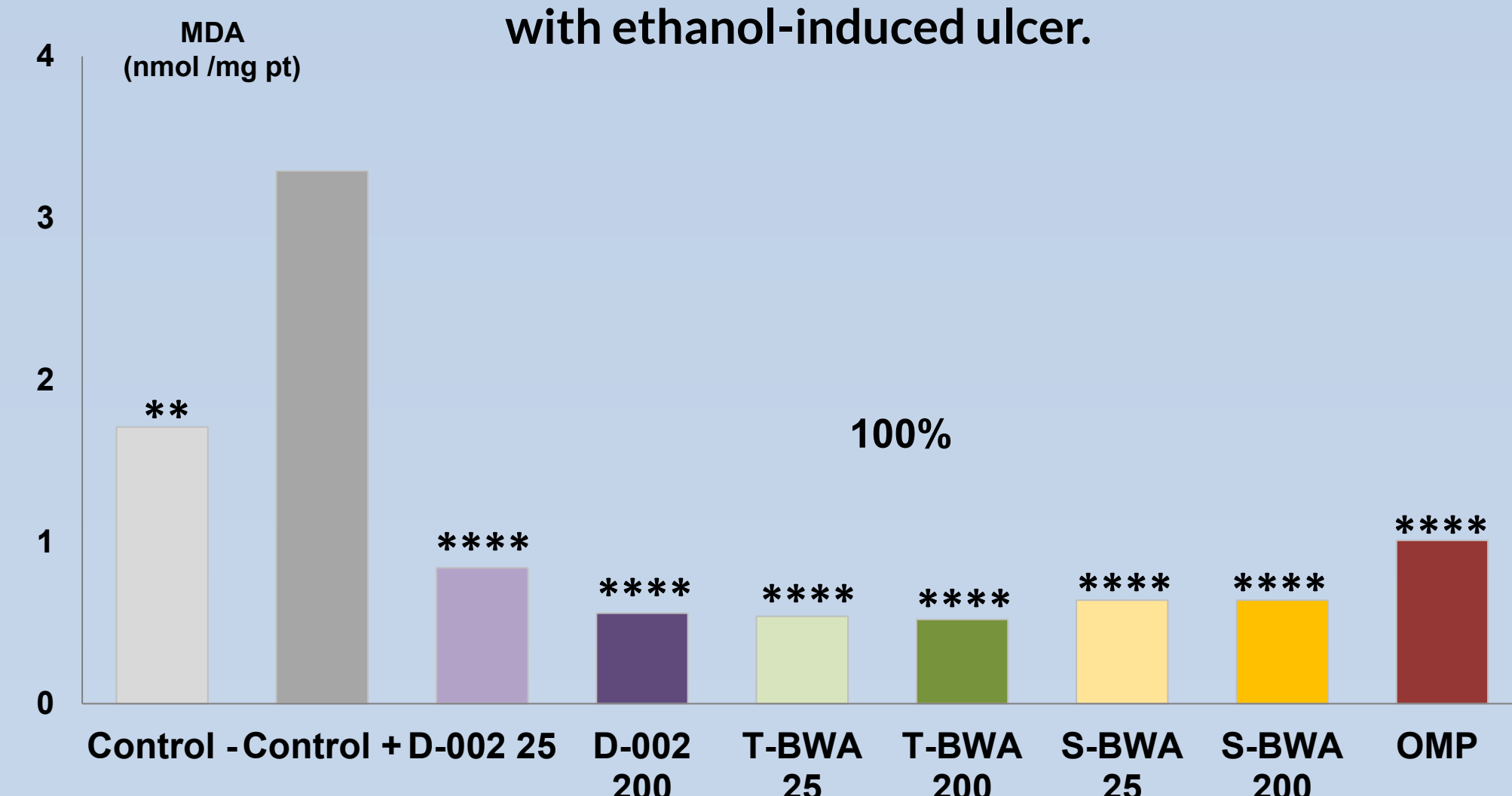
D-002, tablets and suspension were evaluated at the doses of 25 and 200 mg/kg

RESULTS

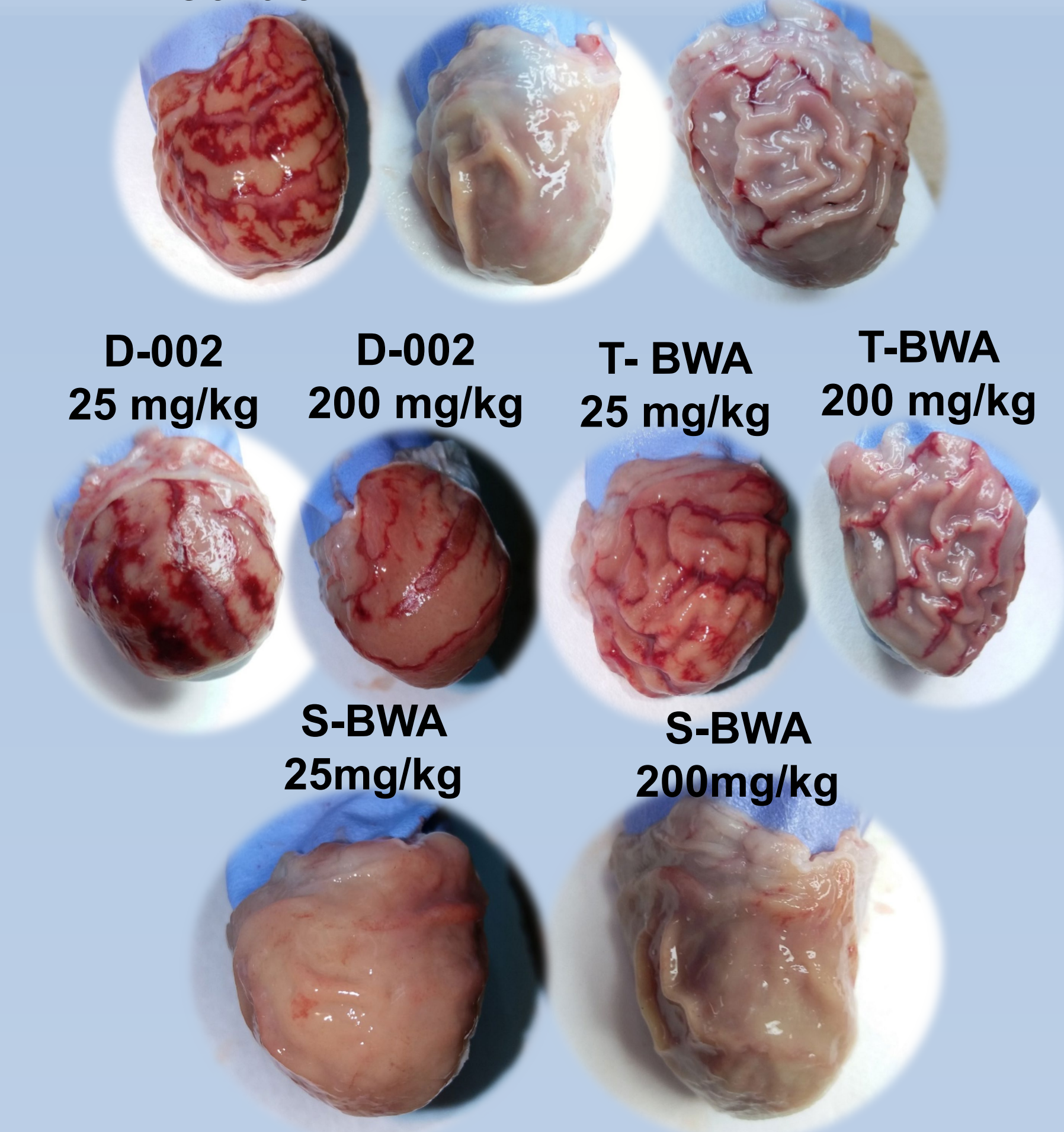
Effect of oral administration of D-002, Tablet BeesWax Alcohol (T-BWA) and Suspension BeesWax Alcohol (S-BWA) on lesion size and mucus content and quality in gastric mucosa of rats with ethanol-induced ulcer.



Effects of D-002, Tablet-BWA and Suspension-BWA on MDA in gastric mucosa of rats with ethanol-induced ulcer.



Positive Control Negative Control Omeprazole



CONCLUSIONS

BWA suspension protects against ethanol-induced gastric ulcer in rats, with greater efficacy than BWA tablet and D-002.

RECOMMENDATIONS

Conduct clinical trials to confirm the efficacy of Abexol suspension vs tablet-BWA in patients.

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