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Presented by

Laouachria Rahma Sacia

Rachedi Hind

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**Antioxidant and immunomodulatory proprieties of
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JURY:

Chair: BOUTEFAHA Zineddine

Supervisor: AMRAOUI Nacer

Examiner: CHENITI Wafa

MCB. UFA Setif 1

MCA. UFA Setif 1

MAA. UFA Setif 1

Laboratory of Applied Biochemistry

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Dedicate

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"Sometimes, the wrong train takes you to the right station."

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Abstract

Papaver rhoeas belongs to the family of “Papaveraceae”. It was used since ancient times for its healing properties. Our study aims to evaluate the antioxidant and immunomodulatory activities of *P. rhoeas* hydromethanolic extract. The determination of total polyphenols and flavonoids contents were carried out using colorimetric methods, using Folin-Ciocalteu and aluminum chloride (AlCl_3), respectively. Antioxidant propriety was tested using free radical scavenging activity against 2,2-diphenyl-1-picrylhydrazyl (DPPH), with BHT as a standard. The effect of *P. rhoeas* extract on the humoral immune response was evaluated *in vivo* in mice injected with sheep red blood cells (SRBC). The total phenolic and flavonoid contents of *P. rhoeas* extract showed $79.64 \pm 5.09 \mu\text{g GAE/mg}$ and $11.07 \pm 0.52 \mu\text{g QE/mg}$ of dry weight of the plant, respectively. *In vitro* antioxidant assay revealed that *P. rhoeas* exhibited a strong antioxidant activity ($\text{IC}_{50} = 104.33 \pm 3.05 \mu\text{g/ml}$) compared to BHT. The immunomodulatory activity showed that the treatment with *P. rhoeas* extract at the dose of 200 mg/kg demonstrated a significant increase in antibody titre (210.44 ± 24.38), while at the dose of 400 mg/kg showed a decrease in this titre (107.55 ± 13.38). In conclusion, the hydromethanolic extract of *P. rhoeas* has potent antioxidant and immunomodulatory activities (immunostimulants at low dose, and immunosuppressants at high dose).

Key words: *Papaver rhoeas*, DPPH, immunomodulatory, polyphenols, flavonoids.

المخلص

ينتمي نبات *Papaver rhoeas* إلى عائلة "الخشخاشيات" (Papaveraceae)، وقد استُخدم منذ العصور القديمة لخصائصه العلاجية. تهدف دراستنا إلى تقييم الأنشطة المعدلة للمناعة والمضادة للأكسدة لمستخلص الهيدروميثانولي لنبات *P. rhoeas*. تم تحديد محتوى عديدات الفينول والفلافونويدات الكلية باستخدام الطرق اللونية، بواسطة كاشف Folin-Ciocalteu وكوريد الألمنيوم ($AlCl_3$) على التوالي. تم اختبار الفعالية المضادة للأكسدة عن طريق إزالة جذر DPPH، باستخدام BHT كمعيار. كما تم تقييم تأثير مستخلص *P. rhoeas* على الاستجابة المناعية الخلطية في الجسم الحي باستخدام الفئران المحقونة بكريات الدم الحمراء للخراف (SRBC). أظهرت نتائج محتوى الفينولات والفلافونويدات الكلية في مستخلص *P. rhoeas* بـ 79.64 ± 5.09 ميكروغرام مكافئ حمض غاليك /ملغ و 0.52 ± 11.07 ميكروغرام مكافئ كيرسيتين /ملغ من الوزن الجاف للنبات على التوالي. أظهر الاختبار المضاد للأكسدة في المختبر أن *P. rhoeas* يملك نشاط مضاد للأكسدة قوي ($IC_{50} = 104.33 \pm 3.05$ ميكروغرام/مل) مقارنة بـ BHT. أظهرت النتائج أن المعالجة بمستخلص *P. rhoeas* بجرعة 200 ملغ/كغ أدت إلى زيادة معنوية في معدل الأجسام المضادة (24.38 ± 210.44)، بينما أدت الجرعة 400 ملغ/كغ إلى انخفاض في هذا المعدل (13.38 ± 107.55). في الختام، يمتلك المستخلص الهيدروميثانولي لنبات *P. rhoeas* نشاطاً قوياً مضاداً للأكسدة ومعدلاً للمناعة (منبه للمناعة بجرعة منخفضة ومثبط للمناعة بجرعة عالية).

الكلمات المفتاحية: *Papaver rhoeas*، DPPH، تعديل المناعة، عديدات الفينول، الفلافونويدات.

Résumé

Papaver rhoeas appartient à la famille des Papavéracées (Papaveraceae). Il est utilisé depuis l'Antiquité pour ses propriétés médicinales. Notre étude vise à évaluer les activités antioxydantes et immunomodulatrices de l'extrait hydrométhanolique de *P. rhoeas*. La teneur totale en polyphénols et en flavonoïdes a été déterminée par des méthodes colorimétriques, en utilisant respectivement le réactif de Folin-Ciocalteu et le chlorure d'aluminium (AlCl₃). L'activité antioxydante a été évaluée par le pouvoir de piégeage des radicaux libres du 2,2-diphényl-1-picrylhydrazyle (DPPH). Le BHT est utilisé comme standard. L'effet de l'extrait de *P. rhoeas* sur la réponse immunitaire humorale a été évalué *in vivo* chez des souris immunisées par les globules rouges de mouton (GRM). L'analyse a montré que la teneur totale en polyphénols et en flavonoïdes de l'extrait de *P. rhoeas* était respectivement de $79,64 \pm 5,09$ µg EAG/mg et $11,07 \pm 0,52$ µg EQ/mg de poids sec de la plante. Le test antioxydant *in vitro* a révélé que *P. rhoeas* présentait une forte activité antioxydante ($IC_{50} = 104.33 \pm 3.05$ µg/ml) comparée à celle du BHT. L'activité immunomodulatrice a montré qu'un traitement avec l'extrait de *P. rhoeas* à la dose 200 mg/kg entraînait une augmentation significative du titre des anticorps ($210,44 \pm 24,38$), tandis que la dose 400 mg/kg provoquait une diminution de ce titre ($107,55 \pm 13,38$). En conclusion, l'extrait hydrométhanolique de *P. rhoeas* possède des activités antioxydante et immunomodulatrice puissantes (immunostimulante à faible dose et immunosuppressive à forte dose).

Mots-clés : *Papaver rhoeas*, DPPH, immunomodulation, polyphénols, flavonoïdes.

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