SHORT COMMUNICATION

In vivo wound healing and antiulcer properties of white sweet potato (*Ipomoea batatas*)

Daniele Hermes a, Débora N. Dudek a, Mariana D. Maria a, Lívia P. Horta b, Eliete N. Lima c, Ângelo de Fátima d, Andréia C.C. Sanches a,*, Luzia V. Modolo b,*

a Centro de Ciências Médicas e Farmacêuticas, Universidade Estadual do Oeste do Parana, Cascavel, PR, Brazil  
b Departamento de Botânica, ICB, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil  
c Faculdade Regional do Vale do Aço, Universidade Presidente Antônio Carlos, Ipatinga, MG, Brazil  
d Departamento de Química, ICEx, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil

Received 13 March 2012; revised 12 May 2012; accepted 5 June 2012  
Available online 6 July 2012

**KEYWORDS**  
White sweet potato; *Ipomoea batatas*; Wound healing; Re-epithelialization; Ulceration index; Free radical scavenging

**Abstract**  
The potential of tuber flour of *Ipomoea batatas* (L.) Lam. cv. Brazlândia Branca (white sweet potato) as wound healing and antiulcerogenic agent was investigated *in vivo* in animal model. Excision on the back of Wistar rats was performed to induce wounds that were topically treated with Beeler’s base containing tuber flour of white sweet potato at 2.5%. Number of cells undergoing metaphase and the degree of tissue re-epithelialization were investigated 4, 7 and 10 days post-treatment. The protective effect of aqueous suspension of tuber flour (75 and 100 mg/kg animal weight) on gastric mucosa of Wistar rats was also studied by using the ethanol-induced ulceration model. Ointment based on white sweet potato at 2.5% effectively triggered the healing of cutaneous wound as attested by the increased number of cells undergoing metaphase and tissue re-epithelialization regardless the time of wound treatment. Tuber flour potentially prevented ethanol-induced gastric ulceration by suppressing edema formation and partly protecting gastric mucosa wrinkles. Crude extracts also exhibited potential as free radical scavengers. The results from animal model experiments indicate the potential of tuber flour of white sweet potato to heal wounds.  

© 2012 Cairo University. Production and hosting by Elsevier B.V. All rights reserved.

**Introduction**  
Wound healing is a process in which an injured tissue tries to repair the damage. It comprises four phases that occur to promote an efficient healing: blood coagulation, inflammation, cell proliferation, lesion contraction and remodeling [1]. The success of this effort depends on complex physiological machinery that involves interactions between a variety of cells, biochemical mediators, and extra-cellular matrix molecules [2]. In skin, cells neighboring a wound (epithelium, fibroblast, and
keratinocyte) migrate to start fibroblast production, followed by extracellular matrix deposition, angiogenesis, healing, and finally epithelial reconstitution [2]. The search for wound healing agents is one of the oldest challenges in medicine and remains a challenge because the tissue repair mechanism is still not fully understood.

Ulcer is an inflammatory process characterized by the loss of epithelial cells from the skin or mucosa. The cure for ulcer involves interactions between various tissue and cell types [3,4]. An ideal antiulcer agent should decrease the inflammation and enhance healing processes [5].

Humans have traditionally used a number of plant preparations to accelerate wound healing even when scientific evidence for their action and/or efficacy is not documented [6–9]. Ipomoea batatas (L.) Lam (sweet potato) is one of the most important food crops in Brazil [10]. Its tubers are largely used for human and animal consumption and also as raw materials for textile, paper, cosmetics and automotive fuels industries [11]. The role of I. batatas tubers on human nutrition, as antioxidant, antidiabetic, cancer-preventive agent [12–14] is well described. The effect of commercially available fibers of Japanese sweet potato and kumara tubers (New Zealand sweet potato) on rat wounds and human health has also been addressed [15,16]. However, no report on the wound healing and antiulcer properties of white sweet potato is documented up to date. Herein, this work brings evidence of the ability of crude flour produced from tubers of a Brazilian white sweet potato variety to heal wounds and protect gastric mucosa from developing ulcer in animal models.

Material and methods

Plant material and preparation of ointment and plant aqueous suspension

Ipomoea batatas (L.) Lam. cv. Brālândia Branca (white sweet potato) was provided by Embrapa Hortaliças (Brasília, Brazil). The species was identified by Dr. João R. Stehman and the voucher specimen deposited in the herbarium of the Department of Botany at the Federal University of Minas Gerais under the number BHCb 157 083. Tubers were grounded to a fine powder that was further dried in the absence of light at room temperature to furnish crude flour. The ointment consisted of Beeler’s base and tuber flour at 2.5%, prepared essentially as described by Lopes et al. [17]. Aqueous suspensions of tuber flour were prepared accordingly to provide doses of 75 mg/kg or 100 mg/kg of animal weight that were used in the experiments of ulceration induction.

In vivo experiments

The Animal Ethics Committee of the State University of West Parana (CEEAAP/UNIOESTE) approved all the in vivo experimental procedures under the protocol number 20/09.

Induction of wounds

Eighteen adult male albino Wistar rats weighing from 200 to 400 g were individually maintained in cages with ad lib water and chow at 22 °C and 12 h photoperiod. After depliation and asepsis, two excisions (1 cm² area each; 2–3 cm apart from each other) were done in opposite sides of the back of each ethyl ether-anesthetized animal. One wounded area was treated with the ointment formulated with tuber flour (2.5%) and the other with ointment base solely, according to the suggested elsewhere [17]. Animals were divided into three groups that were maintained for 4, 7 or 10 days under treatment, and then killed. 2 h prior to the killing, each animal was injected with vincristine sulfate (1 mg/kg body weight) to arrest metaphase of mitosis. Wounded skins were removed from ethyl ether-anesthetized animals, fixed in Buoin’s solution for 2 h and embedded in paraffin. Sections of 10 μm were stained with haematoxylin and eosin and evaluated for epithelial cell growth in the basal and suprabasal layers of re-epithelialization region. Results were expressed in terms of number of metaphase/10 mm. The epithelium length in surface was measured in both re-epithelialization borders of 10 fragments of injured tissues collected from each animal by using an optical microscope (magnification of 10× or 100×). Results were expressed in mm as the length average.

Induction of ulceration

Sixteen adult male albino Wistar rats weighing from 120 to 220 g were divided into four groups. Deionized water and aqueous suspension of tuber flour (75 mg/kg or 100 mg/kg) were administrated through gavage in animals from groups I, II and III, respectively. These doses were chosen to meet the concentration of cimetidine suggested elsewhere [18]. Animals from group IV received cimetidine (100 mg/kg) intraperitoneally. One hour post-treatment, animals received 1 mL of ethanol 96% (v/v) through gavage to induce ulceration [19,20]. After another hour, animals were killed in a CO₂ chamber and the stomach removed for further analysis. Ulceration index was calculated as described elsewhere [21] and the severity of ulceration was classified according to Suffredini et al. [22].

Scavenging of free radicals

The ability of crude extracts of I. batatas tubers to scavenge 2,2-diphenyl-1-picrylhydrazyl (DPPH) radicals was determined according to da Silva et al. [23]. Ethanolic and aqueous crude extracts were prepared by grinding 30 mg of tuber flour in liquid nitrogen and extracting cellular content with 1 mL of ethanol or deionized water. Homogenates were centrifuged at 10,000g and a volume of each supernatant was incubated with equal volume of 100 μM DPPH. The systems were maintained under stirring and absence of light for 30 min and the absorbance recorded at 517 nm. Experiments were performed in triplicate.

Statistical analyses

Data obtained from wound healing and ulcer prevention experiments were analyzed by Student’s t-test (P < 0.05) and non-parametric test one-way-ANOVA (P < 0.05), respectively.

Results

Wounds treated with I. batatas-based ointment exhibited a dry, dark-brown crust thicker than those observed in control
ones, regardless the time of exposure to tuber flour. No exudate or contamination was observed along with the days of wound exposure to the different treatments. The number of cells undergoing metaphase was significantly higher (4.5 fold, $P < 0.001$) in tuber flour-treated wounds 4 days after exposure when compared to non-treated wounds, see Fig. 1. Higher number of cells (ca. 2.5 fold) in metaphase, in comparison with non-treated wounds, was still observed after exposure to *Ipomoea batatas* ointment for up to 10 days. Re-epithelialization process was 43% and 75% more intense in wounds treated with *I. batatas* ointment for 4 and 10 days, respectively, when compared to wounds treated solely with Beeler’s base, see Fig. 1. No significant difference between treatments was observed after 7 days of exposure probably due to the great variability of responses among the tested animals.

The potential of tuber flour of white sweet potato to induce wound healing prompted us to check the ability of this plant material to prevent gastric ulceration. As expected, gastric mucosas treated with deionized water prior to ulceration induction showed widespread edema and absence of wrinkles. The reference drug cimetidine prevented edema formation by 50% while 75% of gastric mucosa surface presented wrinkles. Treatment with aqueous suspensions of tuber flour at 75 and 100 mg/kg prevented edema formation by 75% and 100%, respectively. While tuber flour at 75 mg/kg failed to protect mucosa wrinkles (they were completely absent), 50% of them remained intact when a higher dose of tuber flour (100 mg/kg) was used.

Ulcration index was calculated by considering the severity of gastric mucosal lesions as follows: (I) ulcer area < 1 mm$^2$; (II) 1 mm$^2$ < ulcer area > 3 mm$^2$; and (III) ulcer area > 3 mm$^2$ [21]. Then, the ulceration index was determined according to the formula: $1 \times$ (number of lesions of grade (I)) + $2 \times$ (number of lesions of grade (II)) + $3 \times$ (number of lesions of grade (III)). Ulceration index in gastric mucosas was 2.2- and 3.6-fold lower in animals treated with 75 and 100 mg/kg tuber flour aqueous suspension, respectively, than in those treated with deionized water prior ulceration induction, see Fig. 2. Tuber flour at 75 mg/kg was as effective as the reference drug cimetidine at 100 mg/kg, see Fig. 2.

Considering that the production of free radicals is increased after tissue wounding, crude extracts of *I. batatas* tuber were investigated for the ability to scavenge 2,2-diphenyl-1-picrylhydrazyl (DPPH) radicals. Ethanolic extracts were able to scavenge 20 ± 0.9% of DPPH radicals present in the reaction medium while aqueous extracts at the same concentration captured only 13 ± 0.4% of free radicals ($P < 0.05$; Student’s $t$-test).

**Discussion**

Sweet potato is one of the most consumed vegetables in Brazil. Its tuberous root is also used as a raw material in textile, paper, cosmetic and adhesive industries [11]. Besides its broad use, little is known about the medicinal properties of white sweet potato.

---

**Fig. 1** Effect of tuber flour of *Ipomoea batatas* on cutaneous wounds. (A) Epidermis cells treated with tuber flour-based ointment (2.5%) for 10 days (magnification: 100×). Arrows indicate cells undergoing metaphase. (B) Quantitative analysis of cells in metaphase in wounded epidermis counted in 40 microscope fields (250 μm each). (C) Epidermis cells under re-epithelialization (arrows) 10 days post-treatment (magnification: 10×). (D) Quantification of re-epithelialization. Data are means ± SD ($n = 5$), *$P < 0.05$ compared to control (Student’s $t$-test).
anol-induced gastric ulceration, see Fig. 2. Gastric mucosa pre-
treated with 75 mg/kg was twice as potent as the reference drug
cimetidine (100 mg/kg) partly maintained wrinkles intact. Tuber flour at
75 mg/kg did not protect gastric mucosa wrinkles, a higher concentration
of treatment, see Fig. 1. The wound healing properties of white sweet
potato may be associated to the occurrence of carote-
noids and (poly)phenols known to occur in tubers of this par-
cular plant variety [24,25]. Thus, such metabolites could
account for the control of free radicals that are overproduced
during the inflammation of wounded tissue [1]. Then, the decrease of free radicals in the wounded tissue would somehow
favor its healing. Indeed, in vitro experiments performed with
DPPH free radicals revealed that crude extracts of white sweet
potato tubers (aqueous or ethanolic) were able to scavenge up
to 20% of radicals.

Tuber flour of white sweet potato potentially prevented etha-
olan-induced gastric ulceration, see Fig. 2. Gastric mucosa pre-
treated with an aqueous suspension of tuber flour at 75 mg/kg
twice as potent as the reference drug cimetidine (100 mg/
kg) in preventing edema formation due to ethanol-induced
ulceration. Edemas were completely absent in gastric mucosas
pre-treated with tuber flour at the same concentration of that
used for cimetidine. Although tuber flour at 75 mg/kg did
not protect gastric mucosa wrinkles, a higher concentration
(100 mg/kg) partly maintained wrinkles intact. Tuber flour at
75 mg/kg was shown to be as effective as the reference drug
cimetidine at 100 mg/kg in reducing ulceration index in etha-
olan-induced rats, see Fig. 2. Although tuber flour and cimeti-
dine were administered in rats throughout different routes,
tuber flour of white sweet potato at 100 mg/kg was more effec-
tive than cimetidine at a similar dose, see Fig. 2. Ethanol
causes increased vascular permeability that leads to hemor-
rhagic erosions or edema [26]. Our results suggest that aqueous
suspension of tuber flour prevents edema formation.

Conclusions

Ointment based on white sweet potato promoted the healing of
 cutaneous wounds in experiments performed with animal
models. Suspensions of tuber flour of white sweet potato also
prevented ethanol-induced gastric ulceration while crude ex-
tracts were able to scavenge free radicals in in vitro experi-
ments. To the best of our knowledge, this is the first report
on the potential of tuber crude flour of I. batatas (L.) Lam.
cv. Brazlândia Branca as wound healing and antiulcerogenic
agent in animal models.

Acknowledgements

Authors are grateful to FAPEMIG, CNPq and CAPES for
financing this work. A. de Fátima and L.V. Modolo are sup-
ported by research fellowships from CNPq.

References

[1] de Fátima A, Modolo LV, Sanches ACC, Porto RR. Wound
healing agents: the role of natural and non-natural products in
drug development. Mini Rev Med Chem 2008;8:879–88.
[2] Singer AJ, Clark RAF. Cutaneous wound healing. N Engl J
Med 1999;341:738–46.
[3] Watanabe S, Hirose M, Wang XE, Kobayashi O, Nagahara A,
Murai T, et al. Epithelial–mesenchymal interaction in gastric
mucosal restoration. J Gastroenterol 2000;35:65–8.
[4] Chang WH, Shih SC, Wang HY, Chang CW, Chen CJ, Chen
MJ. Acquired hyperplastic gastric polyps after treatment of
ulcer. J Formos Med Assoc 2010;109:56–73.
[5] Dharmani P, Kuchibhotla VK, Maurya R, Shukla A, Dubey MP,
Srivastava S, et al. Healing potential of Calotropis procera on
dermal wounds in guinea pigs. J Ethnopharmacol 1999;68:
261–6.
[6] Reddy JS, Rao PR, Reddy MS. Wound healing effects of
Heliostemon indicum, Plumbago zeylanica and Acalypha indica
in rats. J Ethnopharmacol 2002;79:249–51.
[7] Deshmukh PT, Fernandes J, Atul A, Toppo E. Wound healing
activity of Calotropis gigantea root bark in rats. J
Ethnopharmacol 2009;125:178–81.
[8] Sünart I, Akkol KE, Keles H, Oktem A, Basar KHC, Yesilda
E. A novel wound healing ointment: a formulation of Hypericum
perforatum oil and sage and oregano oils based on traditional
Turkish knowledge. J Ethnopharmacol 2011;134:89–96.
[9] Yease EA, Borges A, Rosa MS, Queiroz-Silva JR, Bressan EA,
Peroni N. Genetic diversity in Brazilian sweet potato (Ipomoea
batatas (L.) Lam., Solanaceae, Convolvulaceae) landraces
assessed with microsatellite markers. Genet Mol Biol
2008;31:725–33.
[10] Cardoso AD, Viana AES, Matsumoto SN, Neto HB, Khouri
CR, Melo TL. Physical and sensorial characteristics of sweet
potato clones. Ciência Agrotec 2007;31:1760–5.
[11] Ludvik BH, Neuffer B, Pacini G. Efficacy of Ipomoea batatas
(Caiapo) on diabetes control in type 2 diabetic subjects treated
with diet. Diabetic Care 2004;27:436–40.
[12] Rabah IO, Hou D-X, Komine S-I, Fujii M. Potential
chemopreventive properties of extract from baked sweet
potato (Ipomoea batatas Lam. Cv. Koganesengan). J Agric
Food Chem 2004;52:7152–7.
[13] Rautenbach F, Faber M, Laurie S, Laurie R. Antioxidant
capacity and antioxidant content in roots of 4 sweet potato
varieties. J Food Sci 2010;75:C400–5.
[14] Suzuki T, Tada H, Sato E, Sagae Y. Application of sweet potato
fiber to skin wound in rat. Biol Pharm Bull 1996;19:977–83.
[15] Cambie RC, Ferguson LR. Potential functional foods in the
traditional Maori diet. Mutat Res 2003;523–524:109–17.
17 Lopes GC, Sanches ACC, Nakamura CV, Dias-Filho BP, Hernades L, de Mello JCP. Influence of extracts of Stryphnodendron polyphyllum Mart. and Stryphnodendron obovatum Benth. on the cicatrisation of cutaneous wounds in rats. J Ethnopharmacol 2005;99:265–72.

18 Hiruma-Lima CA, Santos LC, Kushima H, Pellizzon CH, Silvera GG, Vasconcelos PCP, et al. Qualea grandiflora, a Brazilian “Cerrado” medicinal plant presents an important antiulcer activity. J Ethnopharmacol 2006;104:207–14.

19 Del Soldato P, Foschi D, Varin L, Daniotti S. Comparison of the gastric cytoprotective properties of atropine, ranitidine and PGE2 in rats. Eur J Pharmacol 1984;106:53–8.

20 Gürbüz I, Üştün O, Yeşilada E, Sezik E, Akyürek N. In vivo gastroprotective effects of five Turkish folk remedies against ethanol-induced lesions. J Ethnopharmacol 2002;83:241–4.

21 Gonzalez FG, Portela TY, Stipp EJ, Di Stasi LC. Antiulcerogenic and analgesic effects of Maytenus aquifolium, Sorocea bomplandii and Zolernia ilicifolia. J Ethnopharmacol 2001;77:41–7.

22 Suffredini IB, Bacchi EM, Sertié JAAA. Antiulcer action of Microgramma squamulosa (Kaulf) Sota. J Ethnopharmacol 1999;65:217–23.

23 da Silva DL, Reis FS, Muniz DR, Ruiz ALTG, de Carvalho JE, Sabino AA, et al. Free radical scavenging and antiproliferative properties of biginelli adducts. Bioorg Med Chem 2012;20:2645–50.

24 Almeida LB, Penteado MVC. Carotenoids and pro-vitamin a value of white fleshed Brazilian sweet potatoes (Ipomoea batatas Lam.). J Food Compost Anal 1988;1:341–52.

25 Teow CC, Truong V-D, McFeeters RF, Thompson RL, Pecota KV, Yench GC. Antioxidant activities, phenolic and -carotene contents of sweet potato genotypes with varying flesh colours. Food Chem 2007;103:829–38.

26 Szabo S, Trier JS, Brown A, Schnoor J. Early vascular injury and increased vascular permeability in gastric mucosal injury caused by ethanol in the rat. Gastroenterolgia 1985;88:228–36.