Journal of Ethnopharmacology 151 (2014) 1019–1022

Contents lists available at ScienceDirect

Journal of Ethnopharmacology

journal homepage: www.elsevier.com/locate/jep

Ethnopharmacological communication

Electrical conductivity measurements of urine as a new simplified method to evaluate the diuretic activity of medicinal plants

Felipe Hernández-Luis [a], Susana Abdala [b,*], Sandra Dévora [b], Dora Benjumea [c], Domingo Martín-Herrera [b]

[a] Departamento de Química Física, Universidad de La Laguna, 38207 La Laguna, Tenerife, Spain
[b] Unidad de Farmacología y Farmacognosia, Facultad de Farmacia, Universidad de La Laguna, 38207 La Laguna, Tenerife, Spain
[c] Departamento de Farmacia, Universidad de Antioquia, Medellín, Colombia

ARTICLE INFO

Article history:
Received 7 October 2013
Received in revised form
29 November 2013
Accepted 29 November 2013
Available online 8 December 2013

Keywords:
Specific electrical conductivity
Urinary excretion volume
Diuretic activity
Medicinal plant

Chemical compounds studied in this article:
Hydrochlorothiazide (PubChem CID: 3639)
NaCl (PubChem CID: 5234)
KCl (PubChem CID: 4873)

ABSTRACT

Ethnopharmacological relevance: Diuretic plants are widely used in traditional medicine in many countries. However, many of these species have not been subjected to experimental studies to confirm that property. In this paper, a simple new method is proposed to evaluate the diuretic activity of plants. We define a new index that takes into account only the volume of urinary excretion and total ion concentration excreted obtained by specific electrical conductivity measurements.

Materials and methods: Urine was collected in a graduate cylinder during the 8 h after *Artemisia thuscula* (AT), *Withania aristata* (WA), *Smilax canariensis* (SC) and HCTZ oral administration to laboratory mice. To obtain the new index Diuretic Power (*DP*), we measured the specific electrical conductivity (κ) of the fresh urine samples. We calculated the concentration of a NaCl (or KCl) aqueous solution that has the same specific electrical conductivity as the urine sample. We multiplied this concentration by the corresponding urinary excretion volume, thus obtaining the total mEq. of electrolyte excreted "as if all were NaCl (or KCl)". Finally, we divided these mEq. by those corresponding to the control to obtain the *DP* value.

Results: HCTZ showed a 40% increase in *DP*, with respect to the control group, independently of the doses used, and the studied plants produced an increase between 7 and 28%. *DP* values were compared with other common indexes, *DI* and *SIi*, showing that the variation sequence of the three indexes was the same for HCTZ, WA and SC.

Conclusions: A new and easy index, that we called diuretic power (*DP*), for estimating the diuretic activity of drugs or plants is proposed. It allows us to highlight diuretic effect with respect to a control value of a large amount of drugs or plants that had not been previously experimentally studied.

1. Introduction

For thousands of years, humans have been using diuretics to reduce the water retention caused by some health conditions such as high blood pressure, heart diseases or pre-menstrual syndrome, among others. Although there is a wide therapeutic stock of synthetic drugs that belong to this pharmacological group, a considerable amount of decoctions and infusions of medicinal plants are used to reduce fluid retention. But the diuretic effectiveness of this kind of medicinal plants needs to be experimentally proved, because diuresis could be influenced not only by the form of administration (infusion or decoction) which implies the consumption of a great amount of liquids that can provoke an increase in the volume of urine excreted without a true evidence of a diuretic action, but also by the difficulty of obtaining reproducible data involving a larger number of animals. Thus, it can be considered of vital importance to validate scientifically this effect taking into account the search for new diuretics derived from plants potentially less toxic than synthetic drugs that could be considered of higher security for patients.

Measurements of urine-specific electrical conductivity have been widely used since the beginning of the last century in different types of studies (Long, 1902, 1904; Shedrovilzky et al., 1961; Hull and Wolf, 1967; Wolf and Pillay, 1969; Kimura and Yokoyama, 1973; Jahrig et al., 1977; Genain et al., 1978; Cunningham et al., 1986; Parkin and Dickinson, 1987; Tiselius, 1992; Kavukcu et al., 1998), many of them related to diuresis, either to estimate variations in ions or total amount of water to be excreted or retained in certain situations (diseases) or upon administering some drugs or herbs.

Specific electrical conductivity, density, and osmolality are physicochemical magnitudes usually employed to estimate the total amount of ions present in a sample of biological fluid such as urine.

* Corresponding author. Tel.: +34 922 318496; fax: +34 922 318514.
E-mail addresses: sabdala@ull.es, suabku@gmail.com (S. Abdala).

0378-8741/$ - see front matter
http://dx.doi.org/10.1016/j.jep.2013.11.059

The last two parameters are strongly affected by the presence of non-electrolytes (glucose, urea …) from the solution and moreover osmolality in particular is not easy to measure accurately.

Specific electrical conductivity is a nonlinear function of the total concentration of ions present in the sample. This electrochemical parameter is non-selective but it is highly sensitive and readily measured. It does not require a large sample, although the temperature must be rigorously controlled for a reliable comparison of results.

To determine diuretic activity after oral administration of various substances (drugs or plants), two parameters are commonly used: the diuretic index (*DI*), defined as the ratio between the amounts of urine excreted from treated subjects and the non-treated control urine volume, and the saluretic index with respect to the excreted ion *i* (*SIi*), defined as the ratio of ion concentration in the treated and non-treated control groups. Usually, *i* stand for Na^+, K^+ or Cl^-.

The aim of this paper is to propose a new index that takes into account only the volume of urinary excretion and the total ions concentration excreted that is easy to measure and affords a reliable description of the diuretic activity of the substances under study, saving time, effort and animals. This new index, that we have called diuretic power (*DP*), is obtained from the specific electrical conductivity measurements and the volume of excreted urine, and we compared it with the data of *DI* and *SIi* obtained from previous studies of our group on the diuretic activity of three endemic plants of the Canary Islands (Benjumea et al., 2005; Martín-Herrera et al., 2007; Abdala et al., 2008).

2. Materials and methods

2.1. Plant material, animals and drugs

The three species studied in this manuscript have been harvested in Canary Islands: *Artemisia thuscula* Cav. (Asteraceae) fresh aerial part in Punta de Hidalgo (Tenerife), *Withania aristata* Ait. (*Solanaceae*) leaves of flowering and immature fruiting in Taganana (Tenerife), and *Smilax canariensis* Willd. (*Liliaceae*) rhizomes, leaves and stems in Las Nieves (La Palma). These plants were identified by Prof. Pedro Pérez de Paz, Department of Plant Biology, University of La Laguna (Tenerife, Canary Islands, Spain), where voucher specimens have been deposited as TFC 44301 (*Artemisia thuscula*), TFC 44393 (*Smilax canariensis*) and TFC 44199 (*Withania aristata*).

Extract preparation, animals, drugs, acute toxicity test and procedures for obtaining samples and measurement units used have been extensively described in previous works (Benjumea et al., 2005; Martín-Herrera et al., 2007; Abdala et al., 2008).

2.2. Methods

Urine was collected in a graduate cylinder with ±0.1 ml precision for two hours during the 8 h after *Artemisia thuscula* (AT), *Withania aristata* (WA), *Smilax canariensis* (SC) and HCTZ administration. To obtain the new index *DP* (Diuretic Power), we measured the specific electrical conductivity (κ) of the urine samples thermostated at 25.0±0.1 °C, with a LF-320 WTF conductivity meter. We calculated the concentration of a NaCl (or KCl) aqueous solution that has the same specific electrical conductivity as the urine sample. Thus, we made a polynomial interpolation of the C-κ data which had been obtained from a wide set of data collected from the literature (Lobo, 1989). Then we multiplied the NaCl (or KCl) concentration by the corresponding urinary excretion volume, thus obtaining the total mEq. of electrolyte excreted "as if all were NaCl (or KCl)". Finally, we divided these mEq. by that corresponding to the control to obtain the *DP* values.

2.3. Statistical analyses

Results are expressed as the mean values ± SEM (standard error of mean). The statistical evaluation was carried out by analysis of variance (ANOVA) followed by Student's *t*-test for multiple comparison. When comparing with control groups, values of *P* less than 0.05 were considered significant.

Table 1
Polynomial fit parameters for the variation C-κ shown in Fig. 1. $C_x = a + b\kappa + c\kappa^2 + d\kappa^3 + e\kappa^4 + f\kappa^5 + g\kappa^6 + h\kappa^7 + i\kappa^8$.

	X: NaCl	X: KCl
a	-1.8435×10^{-6}	-7.0475×10^{-6}
b	8.5309×10^{-3}	7.1925×10^{-3}
c	9.5089×10^{-5}	5.1474×10^{-5}
d	-2.0768×10^{-6}	-8.9095×10^{-7}
e	3.3341×10^{-8}	9.6544×10^{-9}
f	-3.1156×10^{-10}	-5.9261×10^{-11}
g	1.6806×10^{-12}	2.0300×10^{-13}
h	-4.8140×10^{-15}	-3.6060×10^{-16}
i	5.7040×10^{-18}	2.5861×10^{-19}
$\sigma\,(c_x)$	0.0001	0.0008

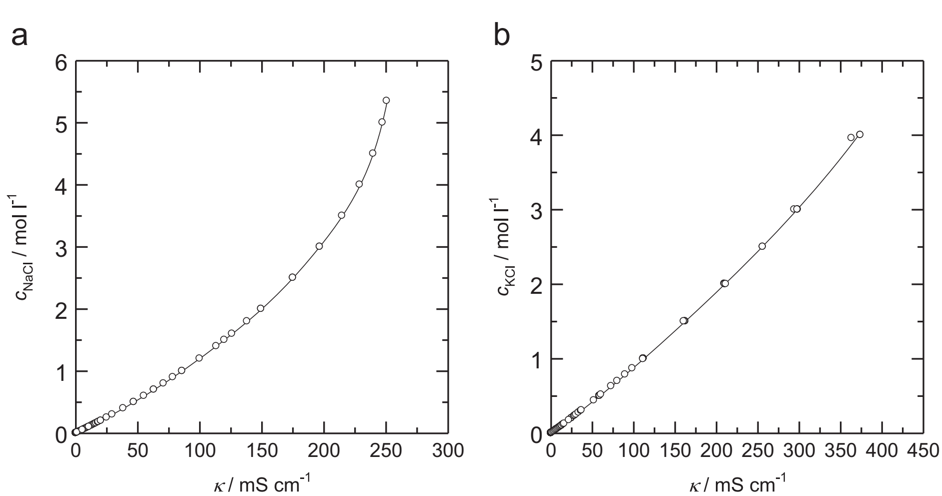

Fig. 1. C_X, vs κ for NaCl (a) and KCl (b) aqueous solutions.