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Botanical quality control of digestive tisanes commercialized in an urban area (Bahía Blanca, Argentina)

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ABSTRACT

Digestive herbal teas in the form of monoherbal infusions or in mixtures are the most commonly used form of phytotherapy in Bahía Blanca (Argentina). This practice is based on family tradition reinforced by current trends reverting to the ingestion of natural products. The objective of this work was to analyze the botanical quality of the digestive mixtures sold in Bahía Blanca as fine cut mixtures (in tea bags) and thick cut mixtures (fragmented herbs). Samples of seven mixtures sold in the form of tea bags and four as bags of fragmented herbs were studied under stereoscopic and optical microscopes and micrographic studies were carried out following conventional protocols. Observed characteristics were compared with those in the reference bibliography for verified genuine monoherbs. In the studied products a total of 21 different species were found. There was total concordance between the species declared on the label and those identified in the samples in six of the mixtures in the form of tea bags and in only one of the bags of fragmented herbs. Adulterations were found in four of the samples analyzed (one in a tea bag and three in the fragmented mixtures). The labels on only two of the tea bag samples presented complete and correct information; in the remaining samples irregularities were found related to: the taxonomic identification of the species, the absence of a lot number, date of expiry, the plant parts used and proportions of the herbs etc. The findings underline the great importance of quality controls as a tool to protect the rights of phytotherapy consumers.

Introduction

Like most countries on the American continent, Argentina is an important repository of knowledge on medicinal plants, reflected in the diversity of these herbs used for specific medicinal purposes. A significant part of this knowledge on medicinal plants comes from the cultural heritage of native inhabitants (Teves et al., 2015). Among Latin American countries, Argentina, Brazil and Mexico are the major players in the herbal market (Sahoo et al., 2010). Some researchers report the expanding commercial availability of herbs and herbal products in Argentina (Pochettino et al., 2008) and a significant growth in the use and retailing of medicinal herbs has been registered in several cities of Buenos Aires Province (Cambi and Hermann, 2001; Pochettino et al., 2008; Hilgert et al., 2010; Arenas et al., 2011; Hernández and Arambarri, 2011; Bach et al., 2014). Further scientific research and dissemination of the findings is required in order to ensure the safety, quality and efficacy in the use of medicinal plants (Teves et al., 2015).

The microscopic and morpho-anatomical characteristics of plant species are of great value for the purposes of scientific investigation and botanical quality control. Morpho-anatomical characteristics can be used to check plant authenticity and contaminations, adulterations and substitutions in plant products. Numerous microscopy analyses are currently requested for the purpose of quality control in products of plant origin.

The method of preparation used to extract the active principle of medicinal plants is of the utmost importance. One of the most widespread preparations is in the form of tisanes, considered home remedies of quick and easy preparation and highly effective. According to the Farmacopea Argentina (2003) a tisane consists of one or more whole, fragmented or chopped plant drugs designed for aqueous preparations by decoction, infusion or maceration. Tisanes to treat different conditions are obtained in fine cut mixtures (tea bags) or thick cut mixtures (fragmented herbs in bags of more than 50 g to be fractioned by the user), both of which must meet the standards that guarantee the quality and safety specified in the Argentine Pharmacopeia. As mentioned above, one of the

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Fig. 1. Location of Bahía Blanca city, Buenos Aires province, Argentina.

methods used to ensure the quality and safety of these products is through micrographic studies.

Bahía Blanca, the study area of this work, is the largest city in the south of Buenos Aires province with a population of more than 300,000 inhabitants (INDEC, 2010), of which according to Cambi and Hermann (2001) between 10% and 30% are medicinal plant consumers. Sedative and slimming mixtures expended in bags of fragmented herbs have been subjected to quality controls in Bahia Blanca (Alza and Cambi, 2009; Turano and Cambi, 2009), but despite being the most common reason for the use of medicinal plants, digestive mixtures (Cambi and Hermann, 2001) have not as yet been analyzed.

The aim of this work was to perform a botanical quality control of the two most common digestive tisane presentation forms in Bahia Blanca – tea bags and fragmented herbs mixtures – by means of micrographic analysis. We therefore evaluated the information appearing on the labels in order to verify whether it conformed to the regulations in force.

Materials and methods

Bahía Blanca is located in the southwest of Buenos Aires province (38°44′ S, 62°16′ W) and is the administrative head of the Bahía Blanca district (Fig. 1).

All pharmacies and herbal stores in the downtown area of the city were visited. The person in charge in each one was interviewed regarding the most frequently selected mixtures of digestive herbs for preparing tisanes. Many of the same brands appeared in several stores and a total of eleven different commercial brands were registered: seven presented as fine cut mixtures (in tea bags) (samples M1 to M7) and four as thick cut mixtures (fragmented herbs in bags of more than 50 g to be fractioned by the user) (samples M8 to M11).

Two packages with different lot numbers were selected from each commercial brand. A pooled sample was then prepared by mixing the contents of each package. Each final sample was obtained by quartering from the pooled sample according to the

Box 1
Micrographic botanical analysis and label appraisal.

Tea bags

Product	Species declared on the label[a]	Species found at micrographic analysis	Adulteration kind	Label irregularities
M1	Coriandro	*Coriandrum sativum*	Addition: *Ilex paraguariensis*	WSN
	Hinojo	*Foeniculum vulgare*	*Senna alexandrina*	WTD
	Manzanilla	*Matricaria chamomilla*		WD
	Menta	*Mentha* × *rotundifolia*		
	Peperina	*Minthostachys mollis*		
	Poleo	*Lippia turbinata*		
M2	Boldo	*Peumus boldus*		WSN
	Carqueja	*Baccharis articulata*		WTD
	Coriandro	*Coriandrum sativum*		WD
	Incayuyo	*Lippia integrifolia*		
	Menta	*Mentha* × *piperita*		
	Peperina	*Minthostachys mollis*		
	Poleo	*Lippia turbinata*		
M3	Cedrón	*Aloysia triphylla*		WSN
	Hinojo	*Foeniculum vulgare*		WTD
	Manzanilla	*Matricaria chamomilla*		WD
	Peperina	*Minthostachys mollis*		
	Poleo	*Lippia turbinata*		
M4	Anis *Pimpinella anisum* Linneo Frutos	*Pimpinella anisum*		
	Boldo *Boldea boldus* (Molina) Looser Hojas	*Peumus boldus*		
	Manzanilla *Matricaria recutita* Linneo Flores	*Matricaria chamomilla*		
	Menta *Mentha piperita* Linneo Hojas	*Mentha* × *piperita*		
	Poleo *Lippia turbinata* (Grisebach) var *integrifolia* Partes aéreas	*Lippia turbinata*		
M5	Boldo	*Peumus boldus*		WSN
	Carqueja	*Baccharis articulata*		WTD
	Cedrón	*Aloysia citriodora*		WD
	Manzanilla	*Matricaria recutita*		WUI
	Menta	*Mentha* × *piperita*		
M6	Boldo	*Peumus boldus*		WSN
	Incayuyo	*Lippia integrifolia*		WTD
	Marcela	*Achyrocline* sp.		WD
	Menta	*Mentha* × *piperita*		
M7	Anis verde (*Pimpinella anisum* L.) Fruto	*Pimpinella anisum*		
	Boldo (*Peumus boldus* Molina) Hojas	*Peumus boldus*		
	Manzanilla (*Matricaria recutita* L.) Inflorescencias	*Matricaria chamomilla*		
	Menta (*Mentha piperita* L.) Hojas	*Mentha* × *piperita*		
	Poleo (*Lipia turbinata* Gris L. fissicaly T) Partes aéreas	*Lippia turbinata*		

Mixtures of fragmented herbs

Product	Species declared on the label[a]	Species found at micrographic analysis	Adulteration kind	Label irregularities
M8	Boldo	*Peumus boldus*	Addition: *Minthostachys mollis*	WSN
	Carqueja	*Baccharis articulata*	*Dysphania ambrosioides*	WTD
	Cedrón	*Aloysia citriodora*	*Aloysia polystachya*	WD
	Incayuyo	*Lippia integrifolia*	*Lippia junelliana*	WLN
	Lucera	*Pluchea sagittalis*		WRN
	Menta	*Mentha* × *piperita*		WUI
	Muña	*Satureja odora*		WED
	Poleo	*Lippia turbinata*		
	Usío	*Aloysia gratíssima*		
M9	Boldo *Peumus Boldus* (hojas)	*Peumus boldus*		WSN
	Cedrón *Aloysia Triphylla* (hojas y tallos finos)	*Aloysia citriodora*		WLN
	Incayuyo *Virginae Excelsis* (hojas y tallos finos)	*Lippia integrifolia*		WD
	Menta *Menta Piperita* (planta)	*Mentha* × *piperita*		
	Peperina *Minthostachys Mollis* (hojas y tallos finos)	*Minthostachys mollis*		
	Poleo *Lippia Turbinatta* (hojas)	*Lippia turbinata*		
	Yerba lucera *Pluchea Sagittalis* (planta)	*Pluchea sagittalis*		
M10	*Aloysia citriodora* Hojas	*Aloysia citriodora*	Addition: *Aloysia gratissima*	WRN
	Baccharis articulata Tallos	*Baccharis articulata*		WUI
	Lippia turbinata Hojas	*Lippia turbinata*		WD
	Melissa officinalis Hojas	*Melissa officinalis*		
	Peumus boldus Hojas	*Peumus boldus*		
	Salvia officinalis Hojas	*Salvia officinalis*		

Box 1 (*Continued*)

Tea bags				
Product	Species declared on the label[a]	Species found at micrographic analysis	Adulteration kind	Label irregularities
M11	Congorosa (*Ilex aquifolium*)		Elimination: *Ilex aquifolium*	WSN
	Incayuyo (*Virginiae excelsis*)	*Lippia integrifolia*	Addition: *Dysphania multifida*	WD
	Manzanilla (*Matricaria chamomilla*)	*Matricaria chamomilla*		
	Menta (*Mentha piperita*)	*Mentha* × *piperita*		
	Peperina (*Bystropogon mollis*)	*Minthostachys mollis*		
	Poleo (*Lippia turbinata*)	*Lippia turbinata*		
	Te andino (*Mendtia calycina*)	*Wendtia calycina*		
	Tomillo (*Hedeoma multiflora*)	*Hedeoma multiflorum*		
	Yerba de Santa María (*Chenopodium ambrosioides*)	*Dysphania ambrosioides*		

Label irregularities: WSN, without scientific name or misspelled; WTD, without responsible technical director; WD, without dosage; WUI, without use indication; WLN, without lot number; WRN, without registration number; WED, without expiration date.

[a] The composition of each product is reproduced as it appears on the label and may therefore contain misspellings in scientific names or authorities.

standardized recommended procedure for quality control methods for medicinal plant materials (WHO, 1998; Farmacopea Argentina, 2003).

The samples were treated by means of the caustic alkali method consisting in hydrolysis of the vegetal material with 5% sodium hydroxide at ebullition for 5–10 min followed by several washes with distilled water in order to disintegrate the tissues (WHO, 1998). The preparations obtained were observed, described and photographed with a Zeiss Axiolab optical microscope. The diagnostic characters of each component were identified through microscope observation and contrasted with those described for each species in the bibliography (Winton and Winton, 1939; Jackson and Snowdon, 1990; Barboza et al., 2001; Upton et al., 2011). When the diagnostic characters of the species found were not described in the bibliography, genuine samples of each monodrug standard sample were made in order to contrast the characters found in the herbal mixtures.

The samples were deposited at the Laboratorio de Biología de Plantas Vasculares (INBIOSUR CONICET-UNS).

Seven categories of label irregularities were established based on a modified version of those reported by Acosta et al. (2017).

Results and discussion

The quality control of the eleven digestive tisanes most used in Bahía Blanca showed that these products were all multicomponent mixtures of four to seven species in the tea bag samples, and six to nine in the fragmented herb samples. Although the number of components of each product was always four or more, the total number of species utilized in their elaboration was only 21 as various species were common components (Box 1). The predominant species in the tea bags were *Lippia turbinata* Griseb., *Matricaria chamomilla* L., *Mentha* × *piperita* L. and *Peumus boldus* Molina, present in five of the seven products under analysis. The predominant species in the mixtures composed of fragmented herbs were *L. turbinata*, present in the four commercial products analyzed, and *Aloysia citriodora* Palau, *Lippia integrifolia* (Griseb.) Hieron., *Mentha* × *piperita* and *Peumus boldus*, found in three of the brands.

Mentha × *piperita*, *Peumus boldus* and *Baccharis articulata* (Lam.) Pers. are all important components of preparations of herbal drugs frequently sold on the local market for the treatment of gastrointestinal disorders according to the Vademecum Nacional de Medicamentos edited by the ANMAT (National Administration of Drugs, Food and Medical Technology, Argentina). However, *Cynara scolymus* L., the principal constituent of phytotherapy preparations owing to its hepatoprotective properties, was absent in the herb mixtures, perhaps because of its bitter taste. In this connection, Alonso (2016) suggests associating this species with an organoleptic flavor corrector to reduce the bitterness.

The product composition as declared on the labels coincided fully with the findings of the microscope analysis for six of the brands marketed as tea bags and one brand of chopped herb mixtures, thus confirming their authenticity. On the contrary, some degree of adulteration was observed in one of the tea bag brands and in three of the fragmented herbal mixtures (Box 1). In sample M1 we detected two additions: *Ilex paraguariensis* A. St. Hil. and *Senna alexandrina* Mill. *Ilex paraguariensis* was identified by the presence of upper epidermal cells with straight cell walls without stomata, lower epidermal cells with ciclocitic stomata and druses (Fig. 2A–C) and *S. alexandrina* by the presence of parenchymatous cells containing polyhedral crystals of calcium oxalate (Fig. 2D). Sample M8 contained four additions: *Minthostachys mollis* (Benth.) Griseb., revealed by the observation of fragments of calix, glandular and eglandular pluricellular trichomes (Fig. 2 E-G); *Dysphania ambrosioides* (L.) Mosyakin & Clemants, identified through the observation of glandular vermiform trichomes and crystal sand (Fig. 2H and I); *Aloysia polystachya* (Griseb.) Moldenke, identified by the presence of eglandular cystolitic conical 1–2 cellular trichomes on the adaxial epidermis, eglandular conical 1–2 cellular trichomes and glandular trichomes with 1–2 cells stalk and 1 cell head on the abaxial epidermis (Fig. 2J and K) and *Lippia junelliana* Moldenke, characterized by glandular trichomes with two cells stalk and one or two cells head longitudinally arranged and eglandular unicellular cystolitic trichomes surrounded by a cushion of cystolitic cells (Fig. 2L–N). Sample M10 revealed one addition: *Aloysia gratissima* (Gillies & Hook.) Tronc. identified by the observation of eglandular verrucous 1–2-cellular trichomes and glandular trichomes with one cell head and one cell stalk (Fig. 2O). Sample M11 showed one elimination: *Ilex aquifolium* L., and one addition: *Dysphania multifida* (L.) Mosyakin & Clemants L., identified through the fruits found (Fig. 2P). In relation to the elimination, it is worth noting that the label included a component registered as "Congorosa" (*Ilex aquifolium*); however, the micrographic analysis revealed neither *I. aquifolium* (commonly named holly) nor *Maytenus ilicifolia* Mart. ex Reissek (commonly named congorosa) to be present. Fungal contamination and foreign matter such as small stones and sand were registered in M5 and M6. The diagnostic characters of the genuine components observed in the microscope analysis are listed in Box 2.

Different types of adulterants were found. The presence of *Ilex paraguariensis* as an adulterant in one product could be an

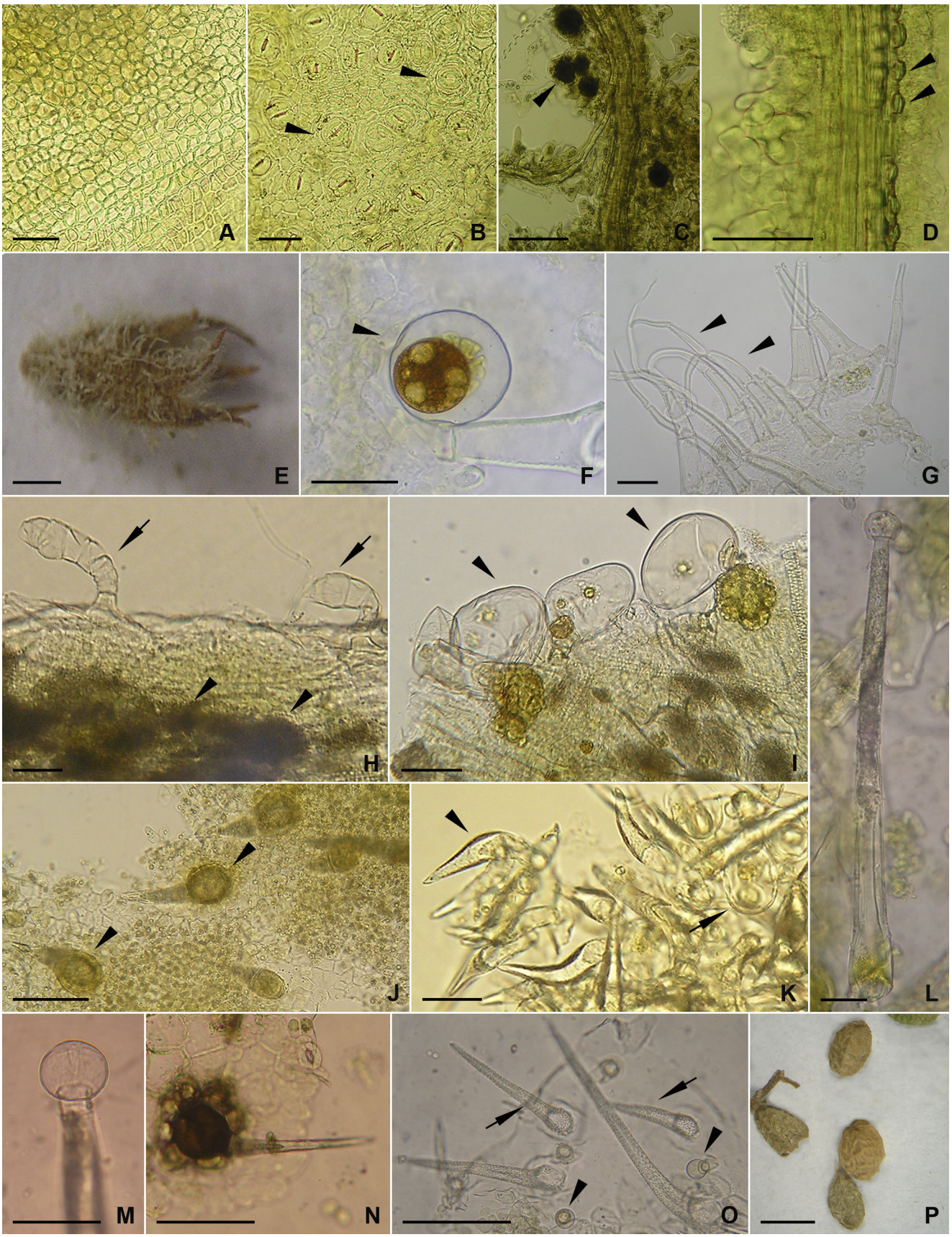

Fig. 2. Adulterants. *Ilex paraguariensis*: adaxial epidermis (A); abaxial epidermis with ciclocitic stomata (arrowheads) (B); druses (arrowhead) (C). Crystaliferous parenchima in *Senna alexandrina* (arrowheads) (D). *Minthostachys mollis*: calix (E); glandular pluricellular trichome (arrowhead) (F); eglandular verrucous pluricellular trichome (arrowheads) (G). *Dysphania ambrosioides*: glandular vermiform trichomes (arrows) and crystaliferous sand (arrowheads) (H); glandular trichomes with unicellular piriform head and short unicellular stalk (arrowheads) (I). *Aloysia polystachya*: adaxial epidermis with eglandular cystolitic conical 1–2 cellular trichomes (arrowheads) (J); abaxial epidermis showing

involuntary addition since the manufacturing company also processes "yerba mate" consisting of *I. paraguariensis* stem and leaf. Since *I. paraguariensis* has digestive properties (Souza et al., 2015) it can be presumed that the presence of this species does not constitute a severe adulteration. However, *Senna alexandrina* as an adulterant is worrying since this species exhibits mild laxative effects (Alonso, 2016). *Dysphania ambrosioides* (syn: *Chenopodium ambrosioides*) was also found as an adulterant; even though this species has been used in traditional medicine as an antispasmodic and digestive drug, it also has an antihelminthic effect and its ascaridol content makes it potentially toxic (Gómez Castellanos, 2008). *Dysphania multifida* (syn: *Chenopodium multifidum*) presents a similar case; it has antacid properties (Teves et al., 2015) but has been demonstrated to induce strand breaks in DNA (Carballo et al., 2005). Furthermore, according to article N° 1788/2000 (annex VI of supplement VIII of phytotherapeutic drugs) of ANMAT regulations, neither of these latter two species are permitted as phytotherapeutic drugs.

Aloysia polystachya, *A. gratissima* and *Minthostachys mollis* were found as additions but are all recognized as being eupeptic and are used for gastrointestinal disorders (Consolini et al., 2011; van Baren et al., 2014). *Lippia junelliana* (Moldenke) Tronc., also found to be an addition, is traditionally used to treat stomach pain and diarrhea (Martínez, 2011).

The presence of *Aloysia gratissima* as an adulterant in samples containing *Lippia turbinata* was reported by Bassols and Gurni (1998) in the local markets of various provinces.

The adulteration of tisanes with some of the above species would therefore appear not to constitute a serious problem since they have some kind of effect on the gastrointestinal system, sharing an ethnomedical application. Nevertheless, sufficiently rigorous controls should be put in place to prevent the addition of unmarked components, however harmless, in order to ensure the quality of the product.

Only two tea bags had labels showing the correct and complete information according to ANMAT requirements (annex IV of disposition 5418/ANMAT, 2015), the rest presenting some kind of irregularity (Box 1). The most frequent irregularities were: in nine labels, the lack of a dosage recommendation; in eight labels, the absence of the scientific name or a misspelling of the name; and in six samples, the lack of information relating to the technical director.

In two products lacking the scientific names of the species, the label indicated the presence of mint. Upon analysis we found *Mentha* × *rotundifolia* (L.) Huds. had substituted for the most commonly used mint in herbal mixtures, *Mentha* × *piperita*. Although *M. rotundifolia* is not the predominant species in digestive mixtures studies report it to have stomachic, antiemetic, carminative, choleretic and antispasmodic properties (Fatiha et al., 2015). Del Vitto et al. (1998) have registered the presence of several mint species, including *M. rotundifolia*, sold and used as digestive, spasmolytic and carminative agents both in popular and official regional medicine. The component M6 called "marcela" could not be identified at the specific level since the observed characters -flagelliform trichomes and fragments of inflorescences with 3–4 phyllary rows- are common to *Achyrocline satureioides* (Lam.) DC ("marcela blanca") and *A. flaccida* (Weinm.) DC. ("marcela amarilla"). However, it could be demonstrated that *Gnaphalium gaudichaudianum* DC. ("marcelita", "vira vira") was not present in the sample. The absence of the scientific name for "marcela" was an added complication. The inflorescences of the species known as "marcela" (*A. satureioides*, *A. flaccida*, *G. gaudichaudianum*) are used in folk medicine and since their exomorphological characteristics at the vegetative phase are similar and they cohabit in nature, they are collected indiscriminately (Gattuso et al., 2008). The species *A. satureioides* and *A. flaccida* have been recognized as effective in treating gastrointestinal illness (Gattuso et al., 2008). The absence of scientific names often leads to confusion, misinterpretation and dangerous substitutions, usually involuntary (Lujan and Barboza, 2008). Quality control of the exact components cannot be carried out if labels do not provide complete information, with the correct scientific names of the component herbs.

Spelling errors were found to be common in scientific names and in one product (M8) the vernacular name appeared to be inexistent ("usío" instead "usillo"), thus hindering the task of botanical recognition.

Another recurrent labeling mistake was the absence of information regarding the technical director, who is responsible for controlling all the processing stages up to the commercialization of the herbs: cultivation, collection, transport, storage and distribution as well as species identification and label information (Lujan and Barboza, 2008). Only two commercial brands met with all the requirements established by the ANMAT.

Even though most of the commercial brands analyzed showed good botanical quality, the labeling deficiency is disturbing since it was highly commercialized top brands that were analyzed, which one would assume gives a certain guarantee of quality. As in other urban areas of Buenos Aires province (Pochettino et al., 2008; Cuassolo et al., 2010; Hilgert et al., 2010; Hurrell and Puentes, 2013; Varela et al., 2014), the products sold were characterized by scarce or invalid consumer information.

Species' common names, plant parts used, documented and updated digestive properties and the micrographic diagnostic elements for each of the species are summarized in Box 2 (in alphabetical order). All species have defined properties for treating digestive disorders. Of the 21 species, eleven had antispasmodic properties, ten had eupeptic action, seven were carminative, six had antiulcer properties, five were anti-inflammatory, four had hepatoprotective action, three were antiemetic, two had coleretic and cholagogue action, two had antimicrobial properties, two were antihelminthic and two had antacid action. All species represented in the samples possessed at least two digestive properties supported by scientific, phytochemical and pharmacological validation. Based on the species composition of mixtures it can conclude that all commercial products had antispasmodic, antiulcer, eupeptic, and carminative properties, whereas nine products had hepatoprotective properties.

A slight tendency toward the use of native species was observed in the specific composition of the products under analysis, more than half the species in the mixtures being native or endemic to the Southern Cone according to Zuloaga et al. (2009). It would be desirable to encourage the use of native species with the aim of developing the Argentinian plant pharmacopeia, at the same time promoting the cultivation of such species and avoiding their indiscriminate collection. Gurni (2007) also proposes that the cultivation of these medicinal species will serve to reduce the number of factors affecting concerning botanical quality. The wide acceptance of

short eglandular conical 1–2 cellular trichomes (arrowhead) and glandular trichomes with 1–2 cells stalk and 1 cell head (arrow) (K). *Lippia junelliana*: glandular trichomes with 2 cell stalk (proximal cell enlarged and distal cell short) and 1 cell head (L) or 2 cells head longitudinally arranged (M); eglandular unicellular cystolitic trichome surrounded by a cushion of cystolitic cells (N). *Aloysia gratissima*: eglandular verrucous 1–2-cellular trichomes (arrows) and glandular trichomes with 1 cell head and 1 cell stalk (arrowheads) (O). Fruits of *Dysphania multifida* (P). Scale bars: A, B: 200 μm; C, D, F, G, H, I, K, L, M, N: 50 μm; E: 10 mm; J, O: 100 μm; P: 20 mm.

Box 2
Species, common names, used parts, documented digestive properties and micrographic diagnostic elements.

Species	Common names	Utilized parts	Principal digestive properties	Micrographic diagnostic elements
Achyrocline sp.[a]	"Marcela"	Inflorescences	Hepatoprotective, choleretic, antispasmodic, antiulcer (Retta et al., 2012)	Eglandular flagelliform 2–8 cellular trichomes arranged in tufts
Aloysia citriodora[a]	Lemon verbena	Leaves and stems	Antispasmodic, eupeptic, carminative, antimicrobial (Alonso and Desmarchelier, 2015)	Poliedric upper epidermal cells without stomata Irregular lower epidermal cells with striated cuticle and anomocitic stomata Eglandular unicellular verrucous cystolitic trichomes surrounded by cystolitic cells Glandular trichomes with 1–2 celled head and 1 cell stalk
Aloysia gratissima[a]	Whitebrush	Leaves and stems	Antispasmodic, antimicrobial, eupeptic (Consolini et al., 2011)	Poliedric upper epidermal cells without stomata Lower epidermal cells with anomocitic stomata Eglandular verrucous 1–2-cellular trichomes Eglandular unicellular conical cystolitic trichomes Glandular trichomes with 1 cell head and 1 cell stalk
Baccharis articulata[a]	"Carqueja"	Aerial parts	Hepatoprotector, choleretic, cholagogue, antiulcer (Alonso and Desmarchelier, 2015)	Striated cuticle; Eglandular flagellated 2–8 cellular trichomes arranged in tufts Glandular trichomes with 1–2 cells head and 1–2 cells stalk
Coriandrum sativum	Coriander	Fruits	Eupeptic, carminative, hepatoprotective (Baghdadi et al., 2016)	Sclerenchyma of the mesocarp composed by masses of thick-walled fusiform cells arranged in several layers at right angles to one another Endosperm cells containing aleurone grains and microrosette crystals of calcium oxalate
Dysphania ambrosioides[a]	Goosefoot	Leaves and fruits	Antihelmintic, antispasmodic, eupeptic (Alonso and Desmarchelier, 2015)	Eglandular whip trichomes with uniseriate 3–8 cellular basal portion and band-like 1–2 cellular apical portion Glandular trichomes with unicellular piriform head and short unicellular stalk Glandular vermiform trichomes Crystaliferous sand in mesophyll
Foeniculum vulgare	Fennel	Fruits	Eupeptic (Uusitalo et al., 2016)	Brown oval mericarps, pericarp with 10 ribs
Hedeoma multiflora[a]	Thyme	Flowers, leaves and stems	Antispasmodic (Dadé et al., 2011)	Diacitic stomata with subsidiary cells of different size Eglandular unicellular verrucous erect trichomes Glandular trichome 8–10 celled head, subsesil Glandular claviform 1 cellular head trichome
Lippia integrifolia[a]	"Incayuyo"	Leaves and flowering tops	Eupeptic, carminative, antispasmodic (Alonso and Desmarchelier, 2015)	Poliedric epidermal cells with straight cellular walls Anomocitic stomata Eglandular unicellular verrucous trichomes Glandular cystolitic trichomes with 1 cell head and 2 cells stalk
Lippia turbinata[a]	"Poleo"	Leaves and flowering tops	Eupeptic,antispasmodic (Pascual et al., 2001)	Isodiametric epidermal cells with striated cuticle, anisocitic and anomocitic stomata Eglandular verrucous cystolitic 1–2 cellular trichomes Glandular trichomes with 1–2 cellular head and 2-cellular stalk.
Matricaria chamomilla	Chamomile	Inflorescences	Antispasmodic, antiinflamatory, antiulcer (Karbalay-Doust and Noorafshan, 2009)	Conical and hollow receptacle Yellowish brown ovoid achenes with 3–5 longitudinal ribs
Melissa officinalis	Melissa, lemon balm	Leaves	Carminative, antihelmintic, antiinflamatory (Fermino et al., 2015)	Epidermal cells with ondulated walls and striated cuticle Diacitic stomata Eglandular verrucous 1– 5 cellular trichomes Glandular 8- cellular trichomes Glandular trichomes with 1 short cell stalk and a 2- cell head Rafids in mesophyll
Mentha × *rotundifolia*	Peppermint, yerba buena	Leaves	Stomachic, antiemetic, carminative, choleretic and antispasmodic (Fatiha et al., 2015), antacid (Teves et al., 2015)	Eglandular conical pluricellular trichomes Eglandular dendritic trichomes Glandular trichomes with 1 cell head or 8-cellular head
Mentha × *piperita*	Peppermint	Leaves	Antispasmodic, anti-inflamatory, antiemetic, carminative (de Sousa Barros et al., 2015)	Epidermal cells with undulated walls, diacitic stomata Eglandular unicellular verrucous trichomes Small glandular trichomes 1-celled head and 2-celled stalk Large glandular trichomes with pluricellular head and short stalk
Minthostachys mollis	"Peperina"	Leaves, young stems	Carminative, antispasmodic, eupeptic (Schmidt-Lebuhn, 2008)	Irregular epidermal cells with undulated walls Diacitic stomata Eglandular verrucous uni to pluricellular trichomes
Peumus boldus[a]	"Boldo"	Leaves	Hepatoprotective, antioxidant, antiulcer (Teixeira et al., 2016)	Eglandular multicellular stellate trichomes Eglandular unicellular trichomes Oil secreting cells in mesophyll Rafids in mesophyll

Box 2 (*Continued*)

Species	Common names	Utilized parts	Principal digestive properties	Micrographic diagnostic elements
Pimpinella anisum	Anise	Fruits	Antispasmodic, antiulcer, antiemetic (Ghoshegir et al., 2015)	Brown piriform cremocarps, pericarp with 5 undulated ribs Eglandular unicellular trichomes in epicarp
Pluchea sagittalis[a]	"Yerba lucera"	Leaves	Cholagogue, carminative, antispasmodic (Campos-Navarro and Scarpa, 2013)	Eglandular flagellate uniseriate 5–10 cellular trichomes Glandular biseriate trichomes with unicellular stalk and a body with 5–7 cellular rows
Salvia officinalis	Sage	Leaves	Eupeptic, antiinflamatory, antiulcer (Walch et al., 2011)	Isodiametric epidermal cells with straight cell walls, diacitic stomata Eglandular 1–3 cellular trichomes Glandular trichomes with bicellular head and unicellular stalk Glandular trichome with unicellular head and bicellular stalk Glandular trichome with 4–12 cellular head and unicellular stalk
Satureja odora[a]	"Muña"	Leaves and stems	Carminative, antiemetic,eupeptic (Tepe and Cilkiz, 2015), antacid (Teves et al., 2015)	Eglandular 2–4 cellular trichomes Glandular trichomes with unicellular head and bicellular stalk Sunken glandular trichomes with pluricellular head
Wendtia calycina[a]	"Te andino"	Leaves and stems	Antacid (Teves et al., 2015), anti-inflamatory (Mesa et al., 2011)	Epidermical rounded or elongated cells with thin cuticle Eglandular unicellular curved trichomes with acute apex and wide base

[a] Native species.

the use of phytomedicines in Argentina testifies to the huge potential for the development of this industry in the country (Bach et al., 2014). The fact that native and exotic species coexist in the commercial mixtures under analysis could be interpreted in terms of the urban ethnobiology concept as species fusion and juxtaposition, a process described by Ladio and Albuquerque (2014) as a kind of hybridization in Latin American urban areas.

Eight species were absent from the list of vegetal drugs of long tradition use (ANMAT, 2009 annex VIII phytotherapic drugs); *Coriandrum sativum*, *Hedeoma multiflora*, *Mentha* × *rotundifolia*, *Minthostachys mollis*, *Pluchea sagittalis*, *Salvia officinalis*, *Satureja odora* and *Wendtia calycina*. Four of these species, *Coriandrum sativum*, *Hedeoma multiflora*, *Mentha* × *rotundifolia* and *Salvia officinalis*, are listed as herbal condiments in the Código Alimentario Argentino (ANMAT article 1199 of Código Alimentario Argentino).

Conclusion

The highest number of adulterations and label irregularities were found in the mixtures of fragmented herbs. The tea bags on the other hand showed for the most part good quality and one of them was the only product to meet with all the requirements of ANMAT in terms of botanical quality and label information and is recognized as an herbal drug at the Vademecum Nacional de Medicamentos. Based on the current legislation (ANMAT Disposition 5418/ANMAT, 2015) the products containing herbal parts, such as those analyzed in this work, must be declared as herbal drugs and must include an information pamphlet clearly stating the therapeutic action and indications for use.

In general, the studied tisanes had an acceptable botanical quality which to our understanding is related to the fact that they were mostly elaborated by laboratories with an experienced commercial history, as is to be expected in an urban area the size of Bahía Blanca where the informal market plays a limited role.

Pathologies of the digestive tract constitute a highly significant sociomedical problem in terms of their occurrence in the population, the rate of morbidity, and the costs they generate for the health system in Argentina (Teves et al., 2015). In fact, a study carried out in a district of Buenos Aires (the capital city of Argentina) on the sale of medicinal herbs at pharmacies and specialized herb stores, showed that the second most demanded mixes of species after those with slimming properties were those with digestive properties (Bach et al., 2014).

In Argentina, as in much of the world, access to herbal medicines is steadily growing, as can be seen in the increased sales in pharmacies and herbal markets (Lujan and Barboza, 2008; Teves et al., 2015). Precise knowledge of the quality of commercial products is crucial for validating the use of herbal medicines. There is an evident need to improve the official monitoring of quality of herbal products, a basic requirement to ensure safety and efficiency parameters to protect consumer interests (Gattuso, 2013). In this sense, studies that contribute to the botanical identification in herbal products are necessary. In the current context, analytical micrography stands out as a helpful, reliable and accurate technique (Gattuso, 2013).

Within Mercosur, the Argentinian and Brazilian Pharmacopeias are the only valid ones (Bandoni, 2011). Only five species of the total present in the commercial samples studied here appear in monographs in the Farmacopea Argentina, pointing out the need for further studies on medicinal species in order to achieve an effective quality control. In particular, it would be desirable to incorporate native species into official publications such as the Farmacopea Argentina or the Código Alimentario Argentino and thereby validate phytotherapy for health care.

Authors' contributions

KMM and VPC contributed in obtaining plant samples, identification, carrying out the laboratory work, analysis of the data and preparation of the paper. VNC supervised all laboratory work and contributed to the preparation of the paper and critical reading of the manuscript. All the authors have read the final manuscript and approved the submission.

Conflicts of interest

The authors declare no conflicts of interest.

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