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Beneficial effects of *Aloe vera* gel on lipid profile, lipase activities and oxidant/antioxidant status in obese rats

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ABSTRACT

Natural products can be very effective in the prevention of obesity-related metabolic disorders. The aim of the present study was to investigate the anti-obesity effects of *Aloe vera* (*Aloe barbadensis* Miller) gel administration at 100 and 200 mg/kg/day, in a diet-induced obesity rat model. The whole gel was used. Plasma and tissue parameters and adipose lipase activities were determined. Our results emphasized that obese rats displayed dyslipidemia and stress oxidative, with excessive adipose tissue lipids. *Aloe vera* gel administration at 100 and 200 mg/kg/day prevented adipose tissue accumulation and corrected the dyslipidemia and oxidative stress. In addition, it induced adipose LPL inhibition and HSL activation in obese rats. In conclusion, *Aloe vera* reduced fat accumulation via its protective role against obesity-related metabolic alterations and antioxidant effects. *Aloe vera* has great potential as functional foods in the activation adipose lipolysis and the prevention of obesity-related metabolic alterations.

1. Introduction

Obesity is a chronic disease resulting from the excessive accumulation of body fat. It causes health damage in adults, adolescents and children, both in developed and in developing countries, with significant losses not only in the quality of life, but also in longevity. The prevalence of obesity has been increasing at alarming rates throughout the world, and has become a major health problem in modern society (NCD-RisC, 2017). An imbalance in energy intake and expenditure leads to adiposity. In addition, the consumption of high-fat diet leads to the accumulation of more fat in the adipose tissue and in later stage, fat deposition takes place in non-adipose tissue (e.g., muscle and liver). Moreover, both familial and environmental factors play a significant part in the development of obesity (Duran, Zainalbden, & Kocak, 2017).

Obesity, especially visceral obesity, is strongly associated with the development of the metabolic syndrome, which includes insulin resistance, type 2 diabetes, hypertension, dyslipidemia and cardiovascular disease (Pozza & Isidori, 2018). Perturbed lipid and lipoprotein metabolism is a common feature of obesity, leading to a dyslipidemia. These lipid alterations are risk factors contributing to the prevalence and severity of atherosclerosis and subsequent coronary heart disease (Ståhlman et al., 2013). Currently, lipid lowering therapies are effective and have a key role in the prevention of cardiovascular diseases, but cause adverse reactions (Kobayashi, Kagawa, Narumi, Itagaki, & Hirano, 2008). Therefore, alternative approaches are needed, and natural therapies attract much interest. Plant products are frequently considered to be less toxic and show minimal or no side effects. Several plants have been reported to possess antihyperlipidemic activity (Gamboa-Gómez, Rocha-Guzmán, Gallegos-Infante, & Moreno-Jiménez, 2015). On the other hand, scientific evidence has shown that biomarkers of oxidative damage are high in obese subjects. This chronic oxidative stress is related to inadequate antioxidant defenses and increased free radical formation, especially in excess adipose tissue. As a precursor of the metabolic syndrome as well as other obesity-related

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disorders, increased oxidative stress in accumulated fat should be an important target for the development of new anti-obesity therapies (Imessaoudene et al., 2016). In addition, given the high cardiovascular risk and oxidative stress associated with obesity, the availability of drugs that have antioxidant and lipid-lowering properties can be of considerable clinical value. Different plants contain a wide variety of components with different anti-obesity effects on fat metabolism and oxidation, and for this reason have been studied and reported as useful in the treatment of obesity (Gamboa-Gómez et al., 2015). *Aloe vera* (AV) is a popular plant which has a wide range of medicinal application in Africa (Mahomoodally, 2013; Van Wyk, 2015).

Aloe vera (L.) Burm. fil. (synonym *A. barbadensis* Miller), is one of more than 400 species of Aloe belonging to family of Asphodelaceae (IPNI, 2015; The Plant List, 2013). This plant was described to contain more than 98% of water and a large amount of potentially active compounds including water-soluble and fat-soluble vitamins, minerals, enzymes, polysaccharides, phenolic compounds, organic acids, amino acids, enzymes, sterols and fatty acids (Radha & Laxmipriya, 2015; Zadeh & Kor, 2014).

Scientific evidence suggests that AV has many activities, including anti-oxidant (Kang et al., 2014; Ozsoy, yanardag, Can, Akev, & Okyar, 2008), antidiabetic (Riyanto & Wariyah, 2018), and antihyperlipidemic (Misawa et al., 2012a, 2012b; Nomaguchi et al., 2011; Taukoorah & Mahomoodally, 2016).

The multiplicity of biological activities of AV has been attributed to the variety of its chemical components; indeed, the synergistic relationship between the components could be useful to maintain beneficial effects (Mahomoodally, 2013). Previous studies used alcoholic extracts or unique chemical entities as phytosterols, and few studies used total *Aloe vera* gel (AVG). The mechanism by which AVG exerts its previously reported anti-obesity effects is still unclear. Indeed, little attention has been directed towards the effects of AVG on adipose tissue function and its redox status in the obese state. As far as we know, LPL and HSL in adipose tissue have not been previously investigated simultaneously.

In this study, we used a well known animal model of obesity, induced by “cafeteria diet” that consists of different snack-type foods consumed by humans, to study the effect of AVG on obesity-related biomarkers (body weight, adipose tissue weight, lipid parameters, adipose tissue lipases, oxidative stress). Supplementation with *Aloe vera* gel would constitute an efficient treatment to correct obesity-related alterations, especially hyperlipidemia and oxidative stress.

2. Materials and methods

2.1. Preparation of Aloe vera gel

For the preparation of the gel, mature, healthy and fresh leaves of *Aloe vera* were used. These leaves were washed with water, and then were cut transversely into pieces. The sections were peeled on each side. The thick epidermis was selectively removed and the mucilaginous inner pulp was recovered and homogenized with a hand held blender. AV powder was prepared according to published procedures for long-term preservation (Mude, Somesula, Adi, & Matcha, 2012). The homogenized gel was lyophilized in ALPHA- lyophilizer (BLANC-LABO, S.A.). The powder was stored in dry sterilized containers, and stored at 4 °C until further use. For the administration sample, the dried AV gel powder was suspended in distilled water and the dosage of homogenized suspension was adjusted to 100 and 200 mg/ml.

2.2. Determination of AVG composition

The proximate composition (ash, crude protein, crude lipid, crude fiber, carbohydrates) of the gel was determined following AOAC procedures (AOAC, 1990). Crude protein content was determined using the Kjeldahl method with a conversion factor of 6.25. Lipid content was analyzed gravimetrically following Soxhlet extraction. Crude fiber was estimated by acid/alkaline hydrolysis of insoluble residues. Crude ash content was estimated by incineration in a muffle furnace at 550 °C. The available carbohydrate was estimated by difference of total contents from 100. Total phenolic content was determined colorimetrically using Folin-Ciocalteu reagent with a gallic acid (GA) calibration curve. Results were expressed as mg GA.100 g^{-1} dry matter. Vitamin C was determined by using 2, 6- dichloro-phenol-indophenol dye according to the association of vitamin chemists (AOVC, 1996) method. Estimation of β-carotene was done using a spectrophotometer method after acetone extraction. The absorbance of the extracts was measured at a wavelength of 450 nm and β-carotene content was determined from the molar absorptivity β-carotene E = 2590 at λmax 450 nm (Ball, 1988). All measurements were done in triplicate. The proximate composition of AVG is shown in Table 1.

Table 1
Chemical characterization of *Aloe vera* gel.

Parameters	g/100 g dry gel
Protein	7.14 ± 0.32
Fat	4.30 ± 0.21
Crude fibre	65 ± 1.32
Ash	16.18 ± 0.53
Carbohydrates	7.36 ± 0.22
Total polyphenols	42.56 ± 1.38 (mg GA/100 g dry gel)
Vitamin C	44.68 ± 2.15 (mg/100 g dry gel)
β-carotene	20.87 ± 1.32 (μg/100 g dry gel)

Values are presented as means ± S.D of triplicate assays.

2.3. Phytochemical screening

Preliminary determinations of phytochemical classes which enter in the composition of AVG were possible by conducting a qualitative analysis based on physicochemical reactions. The tests were realized on hydromethanolic crude extract prepared by maceration (Harborne, 1998; Trease & Evans, 1989). The phytochemical screening is shown in Table 2.

2.4. Chromatographic analysis by RP-HPLC-PDA of AVG phenolic extract

RP-HPLC-PDA analysis of phenolic compounds was performed on a Perkin Elmar Flexar system equipped with a binary pump delivery system and an Eclipse ODS Hypersil C18 column (150 mm × 4.6 μm). The mobile phase consisted in solvent A- Acetic acid (2%) and B-Acetonitrile. The gradient elution system was: 5 min with 15% of B; 25 min with 98% of B and 15 min of linear gradient from 95% to 100% of B, after that, 15 min were consisted for equilibration. Flow rate was 0.8 ml/min. The chromatograms were monitored at 280 nm. The compounds identification and peak assignments were done based on their retention times and comparing with standards used. Typical

Table 2
Phytochemical screening of the methanolic crude extract of AVG.

Components	Reagents	Extract of AVG
Alkaloids	Mayer and Wagner	−
Tannins	FeCl3	+
Flavonoids	Mg + +	+ +
Saponins	Foam index	+ +
Coumarins	Fluorescence	+ +
Sterols and triterpenes	Liebermann Buchard	+ +
Free quinones	NaOH	+ +
Anthraquinones	NH_4OH	+ + +
Anthocyans	HCL and ammoniac	+ + +
Reducing compound	s Fehling's solution	+ + +

+ + +: High positive; + +: Moderate positive; +: Light positive; − : Negative.