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Rotas inflamatórias envolvidas na hipertrofia no tecido adiposo e o efeito do Açaí (Euterpe oleracea Martius) na modulação desse processo: uma revisão

Inflammatory pathways involved in adipose tissue hypertrophy and the effect of Acai (Euterpe oleracea Martius) on the modulation of this process: a review

Rutas inflamatorias involucradas en la hipertrofia en el tejido adiposo y el efecto de Acai (Euterpe oleracea Martius) en la modulación de este proceso: una revisión

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Resumo

O tecido adiposo desempenha um papel importante na inflamação crônica e a presença de compostos bioativos nos alimentos tem sido amplamente discutida como um meio de prevenção e tratamento de várias condições patológicas. O objetivo desta revisão é promover uma visão geral e elucidar as vias envolvidas no processo inflamatório crônico desencadeado pela hipertrofia do tecido adiposo e discutir dados relacionados ao uso do Açaí na modulação da inflamação. Inicialmente, foi realizada uma revisão narrativa das vias metabólicas e moleculares envolvidas no processo de inflamação crônica subclínica (NF-κB, AP-1, *crosstalk* entre macrófagos e adipócitos, aumento de LPS e via do Nrf2). Em seguida, uma revisão integrativa foi realizada sobre o efeito do Açaí nos processos de inflamação subclínica crônica em humanos. O banco de dados consultado foi o PubMed, no qual o nome da fruta foi

cruzado com os descritores "inflamação" e "doenças crônicas", priorizando estudos *in vivo* e *in vitro* relacionados à espécie humana, realizados nos últimos dez anos. Observou-se que os efeitos imunomoduladores do Açaí são cada vez mais claros, no entanto, não são suficientes para classificar o fruto como uma ferramenta no tratamento e prevenção de doenças metabólicas. Para possibilitar inferências mais abrangentes, é necessário que estudos futuros incluam a avaliação da biodisponibilidade dos compostos bioativos presentes, além de serem realizados utilizando-se métodos mais adequados, com seres humanos, contendo cálculo do tamanho da amostra, grupo controle e placebo.

Palavras-chave: Inflamação; Açaí; Doenças crônicas não transmissíveis; Euterpe oleracea martius.

Abstract

Adipose tissue plays an important role in chronic inflammation and the presence of bioactive compounds in food has been widely discussed as a means of prevention and treatment of various pathological conditions. The aim of this review is to promote an overview and elucidate pathways involved in the chronic inflammatory process triggered by adipose tissue hypertrophy and to discuss data related to the use of Acai in the modulation of inflammation. Initially, a narrative review was carried out on metabolic and molecular pathways involved in the process of subclinical chronic inflammation (NF-κB, AP-1, cross-talk between macrophages and adipocytes, increased LPS and Nrf2 pathway). Then, an integrative review was carried out on the effect of Acai in processes of chronic subclinical inflammation in humans. The database consulted was PubMed, in which the name of the fruit was crossed with the descriptors "inflammation" and "chronic diseases", prioritizing in vivo and in vitro studies related to the human species, carried out in the last ten years. It was observed that the immunomodulatory effects of Acai are increasingly clear, however, are not enough to classify the fruit as a tool in the treatment and prevention of metabolic diseases. To make possible more comprehensive inferences, it is necessary that future studies include assessment of the bioavailability of the bioactive compounds present, in addition to being performed using more suitable methods, with humans, containing sample size calculation, control group and placebo.

Keywords: Inflammation; Açai; Chronic diseases; Euterpe oleracea martius.

Resumen

El tejido adiposo juega un papel importante en la inflamación crónica y la presencia de compuestos bioactivos en los alimentos ha sido ampliamente discutida como un medio de prevención y tratamiento de diversas afecciones patológicas. El objetivo de esta revisión es promover una visión general y dilucidar las vías involucradas en el proceso inflamatorio crónico desencadenado por la hipertrofia del tejido adiposo y analizar los datos relacionados con el uso de Acai en la modulación de la inflamación. Inicialmente, se realizó una revisión narrativa sobre las vías metabólicas y moleculares involucradas en el proceso de inflamación crónica subclínica (NF-κB, AP-1, diálogo cruzado entre macrófagos y adipocitos, aumento de la vía LPS y Nrf2). Luego, se realizó una revisión integradora sobre el efecto de Acai en los procesos de inflamación subclínica crónica en humanos. La base de datos consultada fue PubMed, en la que se cruzó el nombre de la fruta con los descriptores "inflamación" y "enfermedades crónicas", priorizando los estudios in vivo e in vitro relacionados con la especie humana, realizados en los últimos diez años. Se observó que los efectos inmunomoduladores de Acai son cada vez más claros, sin embargo, no son suficientes para clasificar la fruta como una herramienta en el tratamiento y prevención de enfermedades metabólicas. Para hacer inferencias más completas, es necesario que los estudios futuros incluyan la evaluación de la biodisponibilidad de los compuestos bioactivos presentes, además de realizarse utilizando métodos más adecuados, con humanos, que contengan cálculo del tamaño de la muestra, grupo de control y placebo.

Palabras clave: Inflamación; Açai; Enfermedades crónicas no transmisibles; Euterpe oleracea martius.

1. Introduction

Chronic non-communicable diseases (CNCD) are the main causes of death in the world, and today, in addition to the most common risk factors - excessive alcohol consumption, smoking, physical inactivity, inadequate eating habits, dyslipidemias and obesity -, we have studied its relationship with chronic subclinical inflammation (Gomes, et al., 2016). By promoting harmful stimuli to the organism one can also start the inflammatory process with several types of response in which there is an increase in vessel permeability, in blood flow and in the release of inflammatory intermediates by leukocytes (Bezerra & Oliveira, 2013).

Adipose tissue is considered part of this process of inflammation because it is able to

release mediators involved in this mechanism and food patterns can influence intensifying - refined and processed foods - or reducing the secretion of these mediators - in foods rich in fiber (Wensveen, et al., 2015). In view of these factors, the presence of bioactive compounds in food and its action in the prevention and treatment of several pathological conditions has been discussed (Abrahão, et al., 2010). Such substances can be found in legumes, vegetables, fruits, herbs, among other foods and play diverse effects on the modulation of the inflammatory response (Fan, et al., 2015; Serra, et al., 2013).

In order to evaluate the effects of such components on the body, it is possible to measure both the substances that are considered as inflammatory and those that play an anti-inflammatory role (Tomé-Carneiro, et al., 2012). The consumption of fruits rich in bioactive compounds is able to promote the reduction of markers of inflammation, improvement of lipid profile, increase in insulin sensitivity, reduction of glucose concentrations, and increase of micronutrient concentrations (Rowe, et al., 2011; Stull, et al., 2010; Udani, et al., 2011; Weseler, et al., 2011).

In this sense, the study of the functional properties of food accessible to the population is an important tool so that new forms of prevention and treatment of increasing DCNT are implemented safely. Therefore, the aim of this review is to promote an overview and elucidate pathways involved in the chronic inflammatory process triggered by adipose tissue hypertrophy and to discuss data related to the use of Acai in the modulation of inflammation.

2. Methods

This work is a review divided into two parts. Initially, a narrative review was carried out on metabolic and molecular pathways involved in the process of subclinical chronic inflammation (NF-κB, AP-1, cross-talk between macrophages and adipocytes, increased LPS and Nrf2 pathway) and, when carrying out the research , an illustration was elaborated interconnecting all these elements (Figure 1), to contextualize the theme.

Then, an integrative review was carried out on the effect of Acai (Euterpe oleracea Martius) in processes of chronic subclinical inflammation in humans. The database consulted was PubMed, in which the name of the fruit was crossed with the descriptors "inflammation" and "chronic diseases", prioritizing in vivo and in vitro studies related to the human species, carried out in the last ten years (2010 - 2020). The choice of this time frame was made with the intention of conducting a current research, within the objective of the study.

When performing the initial search, the articles were selected under the following

inclusion criteria: population (human or human cells), intervention (administration of the fruits in question), outcome (measurement of parameters related to inflammation and chronic diseases) and type of study (experimental). Articles that had deficiencies in the methodological description, that did not contemplate the objective of the study, review articles and / or carried out in non-human species, were excluded.

3. Discussion

3.1 The influence of the Epidemiological Transition on the appearance of Chronic Noncommunicable Diseases

The pattern of diseases that affects a population varies according to the season and the conditions of life (Omran, 2005). These variations are called epidemiological transitions and throughout the human evolutionary history, they comprise factors responsible for the changes in the cellular metabolism of the individuals, contributing to the reduction of parasitic and infectious diseases and favoring the occurrence of chronic conditions (Gotileb, Morassutt & Cruz, 2011; Miranda, et al., 2014; Souza, 2010).

The epidemiological transition is strongly influenced by the socioeconomic and demographic profile of the population, including changes in lifestyle and modernization of customs (Omran, 2005). The breakdown in cellular homeostasis is closely related to changes in dietary pattern, exercise practice and other daily life habits because when it comes to chronic diseases, they can be considered to be modifiable risk factors (Malta, et al., 2015; Silva, et al., 2015).

A study that serves as reference to describe that cell metabolism can undergo lifestyle changes is the Economic Genotype Theory, described in 1962 by Neel et al. This theory claims that in the Neolithic period human genetic assemblages that guaranteed less metabolic expense were necessary, so as to enable the survival for long intervals of food shortage and consequently the storage of the greatest possible amount of energy which would be spent in a measured manner (Silveira, et al., 2007). Over time, food inconstancy was replaced by a higher dietary supply, containing substances of high caloric value coinciding with the increase of sedentary lifestyle and several changes in lifestyle; all of which favored the positive energy balance (greater accumulation and lower expenditure), modifying the body's homeostasis and contributing to the appearance of chronic and metabolic pathological conditions (Barbieri & Mello, 2012).

3.2 Hypertrophy of adipose tissue X Subclinical Chronic Inflammation

The positive energetic balance, in turn, is responsible for the hypertrophy of the adipose tissue and for triggering hypoperfusion by compression of the vessels and, consequently, the interruption of the adequate supply of oxygen to the tissues (Wood, et al., 2009). This local hypoxia may lead to death of some adipocytes, in addition to triggering a cascade of inflammatory response, as well as a process of angiogenesis (Leite, et al., 2009; Silveira, et al., 2009). This stimulus favors macrophage chemotaxis in white adipose tissue (TAB) - which differs from the brown adipose tissue (TAM) that works by dissipating energy, is highly specialized in energy storage and has recognized endocrine and metabolic function - inducing the production of pro inflammatory drugs (Grenha, et al., 2013; Leite, et al., 2009).

It is understood that the stimulation of hypertrophy in the TAB culminates in the modification of its cellular composition - a greater presence of CD8 + (cytotoxic) T lymphocytes, Th17, among others -, activating the monocytes by alternative paths and favoring its phenotypic differentiation in profile macrophages proinflammatory activity of the M1 class (Esser, et al., 2014). In non-hypertrophied adipose tissue, there is a greater polarization of anti-inflammatory macrophages, class M2, induced by a major composition of eosinophils, Th2 lymphocytes and regulators (Leite, et al., 2009).

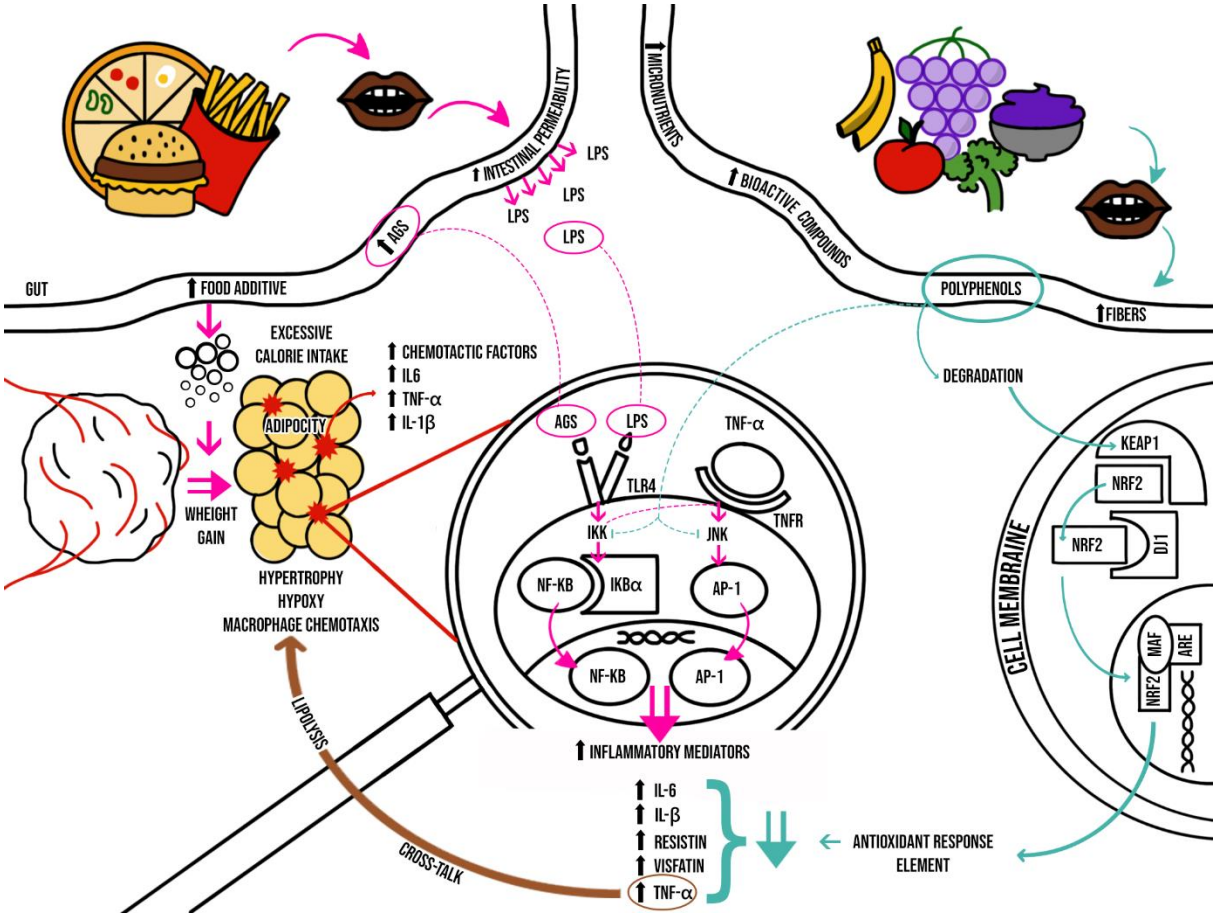
When M1 macrophages are activated, there is an increase in the secretion of adipocytes (cytokines secreted by adipocytes), such as: Interleukin 1β (IL-1β), Interleukin 6 (IL-6), Resistin), Tumor Necrosis Factor (TNF), among other substances (Godoy-Matos, et al., 2014). The increase of these substances causes a local inflammation that, when maintained, plays a crucial role in the triggering of low intensity inflammation at the systemic and chronic level (Bastos, Rogero & Arêas, 2009).

3.3 Pathways involved in the inflammatory process triggered by adipose tissue hypertrophy

The inflammatory process begins with the secretion of certain adipokines which in turn trigger the transcription of genes encoding proteins involved in the inflammatory response, from the activation of signaling pathways of these factors (Bastos, Rogero & Arêas, 2009). The increase of these adipokines in the TAB, such as TNF and IL-1β, for example, activate transcription pathways of genes responsible for the amplification of the inflammation process such as the activator-1 (AP-1) pathway and Jun N-terminal kinase (JNK) (Figure 1)

(Grenha, et al., 2013).

Figure 1. Inflammatory signaling pathways and the influence of diet on the process of exacerbation or modulation of response.



The hypoxia generated by adipose tissue hypertrophy triggers the migration of monocytes and their differentiation into macrophages of the M1 class, with a pro-inflammatory profile. As a result, adipocytes secrete proinflammatory cytokines and chemotactic factors, attracting even more macrophages into its interior. Furthermore, secreted cytokines (TNF-α) cause lipolysis to release fatty acids, which in turn are recognized by macrophages toll-like receptors 4 (TLR4), stimulating the NF-κB → CROSS-TALK pathway. Increasing TNF-α also stimulates the AP-1 pathway. The dietary profile may perpetuate the inflammatory process - by increasing circulating saturated fatty acids (LFAs) as well as lipopolysaccharides (LPS), which also stimulate inflammatory signaling pathways - or inhibit them, as well as stimulate the expression of antioxidant response (Nrf2), minimizing the inflammatory response.
Source: Elaborated by the authors.

Upon contact with its receptor, TNF activates IKK, a kinase protein that promotes phosphorylation of the complex responsible for inhibiting the action of nuclear transcription factor kappa B (NF-κB); after phosphorylation. This complex called the kappa B (IKB-α) nuclear transcription factor inhibitor undergoes ubiquitination and consequent degradation,

leaving NF-κB free to translocate from the cytosol to the nucleus and activate genes encoding inflammatory response proteins such as IL-6, IL-2, INF-γ and Resistin (Basho & Bin, 2010; Li, et al., 2011).

Another way of amplifying the inflammatory process is when pro-inflammatory adipokines react with JNK - a stress-activated kinase protein - that activates AP-1 allowing its migration to the nucleus and, like NF-κB, makes the signal transduction allowing the coding of new proinflammatory proteins and enhancing response (Figure 1) (Esser, et al., 2014) The long-term activation of the immune system is maintained by factors that perpetuate feedback from this cycle; in addition to producing inflammatory cytokines, hypertrophied adipose tissue also releases chemostatic factors that attract circulating macrophages into adipocytes, increasing the infiltrate and hence the response to inflammation (Li, et al., 2011).

This mechanism of feedback is known as the cross-talk between adipocytes and macrophages that, when attracted to the tissue, in addition to producing proinflammatory cytokines, still induce the release of fatty acids inside the adipocytes (Barbieri & Mello, 2012). It is known that lipopolysaccharides (LPS), endogenous and dietary fatty acids, also activate macrophages through Toll-like receptors (TLR-4), thus contributing to the chronicity of the subclinical inflammation process (Figure 1) (Wensveen, et al., 2015).

As the proinflammatory adipokines are secreted by the TAB and reach the bloodstream, they come in contact with the other organs that, in response, also secrete cytokines, increasing the release of mediators of inflammation, generating oxidative stress and maintaining the inflammatory process and low intensity (Li, et al., 2011). In addition to the various forms of stimulation to the inflammatory response, diet is a determining factor (Geraldo & Alfenas, 2008).

In the gut, immune cells are also stimulated when they come in contact with a high fat diet - trans fatty acids and mostly saturated fatty acids, low-glycemic with low fiber intake, rich in food additives and poor in anti-inflammatory and antioxidant foods (Basho & Bin, 2010). This dietary profile not only stimulates the innate immune response, but also favors increased intestinal permeability, which in turn is related to increased circulating LPS and metabolic endotoxemia (Oliveira & Nunes-Pinheiro, 2013).

Thus, the chronic subclinical inflammation state is basically initiated by molecular mechanisms of innate immunity and has as a characteristic the elevation of inflammatory markers and mediators, ranging from the cells of the immune system, as well as the products of its stimulus - acute phase proteins , cytokines, among others - and may culminate in the triggering or aggravation of metabolic diseases such as obesity, hypertension, cardiovascular

diseases, insulin resistance and neuroendocrine (Carvalho, Colaço & Fortes, 2006).

The exacerbated and constant expression of proinflammatory cytokines implies a metabolic and molecular process called chronic subclinical inflammation and can generate or aggravate several pathological conditions (Soares, et al., 2015; Valente, et al., 2014). Thus, ways are sought to minimize this response, repair damage and restore body homeostasis, and in this context, the effect of food on inflammatory mediators is studied (Caballero-Gutiérrez & Gonzáles, 2016; Costa & Duarte, 2006).

In light of this, it is known that certain dietary patterns may exacerbate or minimize chronic subclinical inflammation and that processed foods, refined cereals, whole milk products, soft drinks, sweets and oil additives add an atherogenic profile to the diet with high glycemic load, rich in saturated, trans fatty acids and cholesterol and may favor higher caloric intake, insulin resistance, cardiovascular diseases, oxidative stress, endothelial lesion and pro-inflammatory state; whereas a diet richer in complex carbohydrates, fiber, plant protein, mono and polyunsaturated fatty acids, foods rich in micronutrients and bioactive compounds offer protection against these factors (Bielmann, et al., 2015).

The presence of bioactive compounds in foods has been widely discussed as a tool for prevention and treatment of several pathological conditions (Silva, et al., 2015). These compounds have antioxidant, anti-inflammatory, regulatory capacity and can promote benefits in the body - neutralization of free radicals, modulation of oxidative stress and inflammatory response - and among several existing groups are polyphenols, flavonoids, phytosterols, glucosinolates, carotenoids and isoflavones (Rêgo, et al., 2011).

This neutralization of free radicals and modulation of the inflammatory response by dietary polyphenols may occur in several ways, however, one of the most elucidated mechanisms is the nuclear factor-erythroid 2-related factor-2 (Nrf2) activation pathway (Nguyen, Nioi & Pickett, 2009). Nrf2 is a nuclear transcription factor that induces the expression of antioxidant genes and, under basal conditions, is associated with a protein called Kelch-like ECH-associated protein 1 (Keap1), which prevents its translocation to the nucleus and facilitates their degradation by ubiquitination (Ma, 2013). In stress situations, the Sestrin 2 (Sesn2) protein induces degradation of Keap1 - also degraded by dietary polyphenols - releasing Nrf2, which is phosphorylated and translocate to the nucleus, where it interacts with the antioxidant response element (AER) inducing the expression of antioxidant genes that directly contribute to the reduction of oxidative stress and indirectly promote the suppression of the NF-κB and AP-1 pathways, reducing pro-inflammatory signaling and stimulating the anti-inflammatory response (Albertoni & Schor, 2015; Barbosa, et al., 2016;

Souza, et al., 2010).

3.4 Acai (Brazilian typical fruit) in the modulation of the inflammatory process

Acai is a Brazilian typical fruit, rich in unsaturated fatty acids (Minighin, et al., 2020) and anthocyanins - the largest group of water-soluble pigments in the vegetable kingdom (Oliveira, Costa & Rocha, 2015). The anthocyanins are responsible for a variety of attractive colors of fruits, flowers and leaves, which can vary from red to blue, altering according to the pH of the environment in which they are found (Costa, et al., 2015; Markasis, 1982).

In food, these substances prevent auto-oxidation as well as lipid peroxidation and, in plants, they protect against the action of light and still participate in defense mechanisms and biological functions (Lopes, et al., 2007; Sena, et al., 2015). In the human body, they can act as free radical scavengers and heavy metals, thus preventing the propagation of the inflammatory and oxidative process (Lopes, et al., 2007; Reginato, Silva & Bauermann, 2015; Sena, et al., 2015).

Vizzotto (2012) describes in his study that the therapeutic effects of anthocyanins in promoting human health are more frequent when source foods are consumed in their entire form. This can occur because when isolating an active principle, the synergistic effect between the components of the whole food is lost (Markasis, 1982; Oliveira & Bastos, 2011). When combined with other components, phenolic compounds become less susceptible to interferences caused by digestive processes, such as altered pH and the action of digestive enzymes, and this promotes an increase in the average life and bioavailability of the same, allowing them to act on the different tissues , promoting benefits (Markasis, 1982; Oliveira & Bastos, 2011).

The same context that relates the antioxidant effect of foods to their anthocyanin content was addressed in the review by Cardoso, Leite & Peluzio (2011), which brought together in vitro and in vivo studies conducted from 2006 to 2010 and highlighted the capacity that anthocyanins have to reduce the risk factors for CNCD, by contributing to the reduction of oxidative stress and inflammatory processes.

Supporting the existing literature, in the study by Portinho, Zimmermann & Bruck (2012), antioxidant, anti-inflammatory, immunomodulatory, hypolipidemic, hypoglycemic, anti-carcinogenic and anti-aging effects presented after administration of Acai were highly related to the amount of anthocyanins present in the fruit. As well as the study by Soares et al. (2015) which emphasized that anthocyanins can promote the neutralization of free radicals,

besides the suppression of the production of pro-inflammatory interleukins in acute inflammation processes.

In an in vitro study by Ford et al. (2016) the action of 31 polyphenols extracted from several foods on the release of pro-inflammatory cytokines by CD4 + T lymphocytes was evaluated. Cells were treated with several isolated bioactive compounds (resveratrol, anthocyanins, etc.) and were stimulated with LPS after 5h incubation. Then they incubated for an additional 19 hours, totaling 24 hours. After the intervention, it was possible to realize that polyphenols - including those extracted from Acai - were able to minimize the release of pro-inflammatory cytokines, such as IL-2 and INF-γ.

In this same sense, Poulouse et al. (2012) conducted an in vitro study in which stimulation with 100ng/mL LPS was promoted in four groups of murine BV-2 microglial cells previously treated with different Acai extracts and all fractions of Acai extract were able to attenuate inflammation, minimizing the action of TNF-α and NF-κB. It is known that by minimizing the action of TNF-α and NF-κB on target tissues, the pathways of perpetuating the inflammatory response are suppressed by reducing the expression of other proinflammatory cytokines (Akira, Taga & Kishimoto, 1993; Oliboni, Cesarin & Chielle, 2016).

In another in vitro study, Dias et al. (2015) used non-cancerous human colon myofibroblasts (CCD-18Co) in which antigenic stimulation with LPS was promoted together with different concentrations of polyphenols from Acai. The results were also favorable in demonstrating that the polyphenolic extract of Acai minimized intestinal inflammation by modulating the NF-κB pathway, reducing the expression of genes and cytokines important for the perpetuation of the inflammatory response.

In humans, Pereira et al. (2015) performed a study with eutrophic and overweight women and proposed a daily intervention with the ingestion of 200g of frozen Acai pulp for a period of four weeks. For this, the volunteers were oriented to maintain the lifestyle and include the Acai in the way they preferred. Anthropometric, biochemical and clinical variables were measured at baseline and at the end of the intervention. In general, an increase in PAI-1 (plasminogen activator inhibitor) and EFG (epidermal growth factor), markers of the inflammatory process related to several pathological conditions, was observed. In the eutrophic group, the Acai intervention promoted redistribution of body fat, with subcutaneous reduction and intramuscular and visceral increase. In the overweight group, there was an improvement in insulin sensitivity, as well as the reduction of PAI-1, body fat and blood pressure. In this study, overweight women presented better results in relation to inflammation

and clinical parameters.

Also, in self-controlled intervention with humans, Udani et al. (2011) conducted a pilot study to evaluate the consumption of 100 g of Acai berry twice a day for four weeks and volunteers received nutritional guidelines to change lifestyles, avoiding the consumption of high calorie foods and food additives. At the end of the study a reduction of fasting glucose and insulin, and improvement of the lipid profile were observed, and, besides that, the increase of postprandial glucose and of the area on the glucose curve. Although the study has demonstrated the potential of Acai in the homeostasis of the organism, the researchers made orientations for changes in the food profile and this may be a bias and that reinforces the need to further research the benefits of fruits in human health.

As well as the study by Pereira et al. (2015), studies by Barbosa et al. (2016) and Pala et al. (2017) were performed in a free-living situation and the volunteers were instructed not to perform any kind of modification in the dietary pattern nor related to the practice of physical exercise, in an attempt not to promote any interference with the results. After the four-week intervention with 200 g / day of Acai pulp, Barbosa et al. (2016) noted that the fruit was able to significantly reduce the production of Reactive Oxygen Species (ROS) in polymorphonuclear cells, in addition to increasing the total antioxidant capacity and the activity of the catalase - antioxidant enzyme.

In the study by Pala et al. (2017), before and after the intervention, lipid profile variables, apolipoproteins and biomarkers of oxidation processes were evaluated. The results showed that the daily intake of Acai did not modify the concentrations of HDL cholesterol, triglycerides nor apolipoprotein B (apo B). However, it enabled the increase of the concentration of apo A-I and the cholesterol-carrying protein ester, indicating an improvement in the metabolism of HDL cholesterol. Additionally, it significantly reduced LDL-oxidized concentrations and ROS production by neutrophils

In this sense, Alqurashi et al. (2016) conducted a study to evaluate the acute effect of Acai consumption on markers of cardiovascular diseases in healthy, overweight men. For this, a randomized, double-blind, controlled study was performed in which endothelial function was evaluated by the flow mediated dilatation variable (FMD), before and after the intervention with a smoothie made with Acai and also a control with similar amounts of micronutrients associated with high fat meals. When comparing the intervention with Acai smoothie and control smoothie, participants were found to have improved endothelial function after Acai consumption, indicating their possible cardioprotective effect.

Already in a chronic study by Kim et al. (2018), The consumption of a beverage

prepared with Acai for a period of 12 weeks was able to reduce the plasma IFN and the urinary dosage of 8-isoprostane in individuals with Metabolic Syndrome. This result demonstrates the possible benefits of the fruit in the health conditions that involve inflammation and oxidative stress. However, there was no significant difference in glycemic control and lipid profile variables.

Thus, in vivo and in vitro studies have demonstrated the effective ability of Acai to modulate the inflammatory process strategically, through neutralization of free radicals and participating of several pathways, including that of NF-κB (Barbosa, et al., 2016). These effects suggest that Acai has antioxidant and anti-inflammatory action, however, are not enough to classify the fruit as a tool in the treatment and prevention of metabolic diseases.

4. Conclusions

Based on the articles described in this review, it is possible to see that nutrition plays an important role modulating the pro-inflammatory and pro-oxidative process of the body. When this process occurs in a chronic way, it can be related to negative outcomes on health, aggravating or triggering pathological conditions. Foods rich in bioactive compounds, such as anthocyanins, can act to release mediators that contribute to the achievement of homeostasis in the face of these processes.

Regarding the potential positive effects of Acai, it is possible to notice that its antioxidant and anti-inflammatory action are increasingly clear, especially in in vitro studies. However, these existing studies are still insufficient to confirm that Acai-based foods and supplements are capable of exert a therapeutic effect in the prevention and treatment of chronic diseases.

In order to answer this question, it is necessary further studies, mainly with humans, with more adequate methods and that allow inferences to be made, such as randomized clinical trials, with placebo and sample size calculation. Studies that assess the bioavailability of the bioactive compounds present are also needed. In this way, we can clarify the possible benefits and harms of this strategy and safely decide on its indication as a conduct in clinical practice.

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