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Relationship between citrus and stress, citrus and oxidative stress: a short synthesis

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Abstract
Background. Citrus fruits are beneficial in the fight against all forms of stress, predominating antioxidative actions.
Aims. The objective was to highlight the relationship between citrus and stress, citrus and oxidative stress, in a short synthesis from the PubMed perspective publications.
Methods. To highlight the relationship between citrus and stress, several combinations of keywords were selected: Lemons+Stress (L+S), Orange+Stress (O+S), Grapefruit+Stress (G+S), Lemons+Oxidative Stress (L+OS), Orange+Oxidative Stress (O+OS), Grapefruit+Oxidative Stress (G+OS). PubMed analyzed filter was Species.
Results. The earliest publications were for L and the most recent for G. The most numerous publications were for O. Publications for S were more numerous than OS for all three selected Citrus fruits. Most studies were in humans for O+S and in animals for O+OS. The number of publications related to L+OS, O+OS, G+OS showed an increasing dynamic over time, both for N and for An and H, the highest number being in 2018.
Conclusions. 1) Interest in studies dealing with L+S/L+OS and O+S/O+OS was greater than research interest for G+S/G+OS. 2) Studies on the combination of citrus fruits and S were consistently more numerous, thus proving less interest in research related to L, O and G in relation to oxidative stress. 3) Publications for L, O and G, in combination with S and OS, although more numerous for animals, show that there is a growing interest in research involving human subjects. 4) The number of studies related to the three selected citrus fruits in combination with S and SO had an upward dynamic from the first publication until 2018, proving an increasing interest over time for these subjects.
Keywords: citrus, stress, oxidative stress, PubMed.

Introduction

Citrus fruits are part of the family Rutaceae, subfamily Aurantioideae, of the Citreae. They are fruit trees that give fruits called "citrus", such as: orange, lemon, grapefruit, tangerine, etc. (Mueller et al, 2019). There is a wide variety of citrus fruits: Citrus sinensis - includes oranges, as original fruits; Citrus Limon - includes classic lemons; Citrus reticulata - includes tangerines; Citrus Paradisi - includes grapefruit. We list some important benefits (Chhikara et al., 2018): they are not very caloric; provide useful fibers for the regulation of intestinal transit; provide vitamin C (Baldini et al, 2018); they are rich in minerals, calcium, potassium, magnesium (Czech et al., 2020). The limits of citrus fruit utilization are very low. We list some of them: excessive consumption can lead to hypervitaminosis; too frequent consumption and in large quantities is not recommended. They are beneficial in the fight against all forms of stress, in particular they have an important action against oxidative stress (Mahmoud et al., 2019).

Animal studies have always been a foundation for research and are, in most thematic approaches, the oldest chronologically. On the other hand, in recent years, studies involving human subjects are increasingly numerous, for most subjects involving natural resources and their connection with health, such as plants, fruits or plant extracts.

Hypothesis

Research presents an interest in citrus in general, but citrus and stress, citrus and oxidative stress relationships have very few studies, given the number of publications found on the PubMed site.

Objectives

The objective was to highlight the relationship between citrus and stress, citrus and oxidative stress, from PubMed publications.

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Material and methods

PubMed site was the research database for the obtained information.

Keywords. The selected keywords were: citrus (lemon = lemon = L; oranges = orange = O; grapefruit = G), stress (S) and oxidative stress (oxidative stress = OS).

PubMed filters. The search criteria were represented by the analysis of the *Species* filter with the sub filters: animals (animals = AN), humans (oter animals = H).

Periods of research. The number of publications displayed is the one announced by the site at the date of the search, before the year of the onset of the pandemic, 2018.

Study design. Criteria for the organization were the following:

1) Comparative analysis of the total number of publications, for the chosen key word combinations related to Citrus

2) Comparative analysis of the keyword combinations chosen for S and OS, related to the Speciesfilter

3) Analysis of keyword combinations between the three Citruses and OS, relative to the Species filter

Results

1. Comparative analysis of the total number of publications, for the chosen key word combinations related to Citrus (Fig. 1).

The earliest publications were for L, from 1959, and the most recent, for G, from 1983. Overall, the most numerous publications were those related to O, both for Citrus in general (1986) and for the keyword combinations O+S (1963) and O+OS (729). Comparing the two types of keyword combinations regarding S and OS, it is noted that for all three selected Citrus (L, O, G), studies for S were more numerous than the ones for the OS. The biggest differences between the number of publications related to S and OS were related to O, for N (1986 vs 753) and H (934 vs 324).

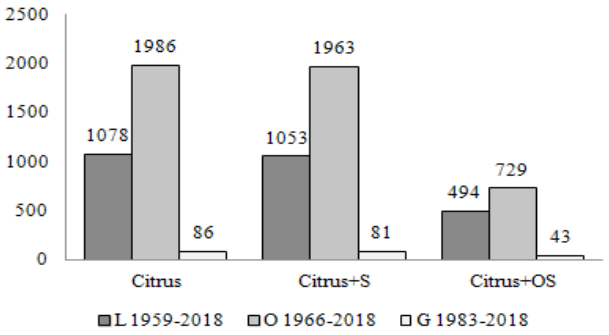

Fig. 1 - Comparative analysis of the total number of publications, for the chosen key word combinations related to Citrus.

2. Comparative analysis of the keyword combinations chosen for S and OS, related to the Species filter (Fig. 2)

For the keywords combination of Citrus + Stress (L+S, O+S, G+S), it is noted that most studies were with human subjects and for O+S (934); the fewest studies were with humans and for G+S (21). For the keywords combination of Citrus + Oxidative Stress (L+OS, O+OS, G+OS), it is noted that most studies were with animals and for O+OS (339); the fewest studies were with human subjects and for G+OS (13).

3. Analysis of keyword combinations between the three Citruses and OS, relative to the Species filter

a) L+OS analysis (Fig. 3; Table I)

The first publications about L+OS were in 1990. The number of publications related to L+OS presented an increasing dynamic over time, both for N and for An and H, the highest number being in 2018 (45.2/year - N; 22.9/year - An; 12.6/year - H). Publications that included human subjects were consistently lower compared to those on animals. The differences between N-An, N-H, An-H were not significant.

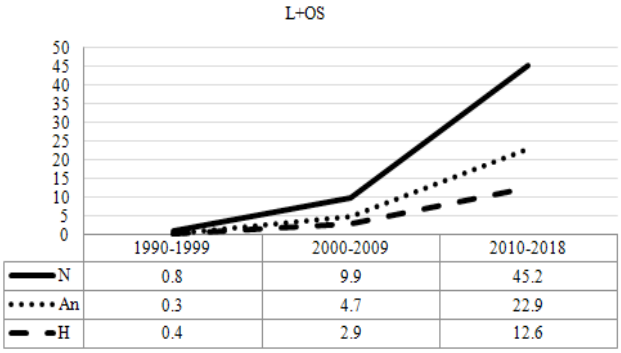

Fig. 3 - Dynamic analysis of N/Year for L+OS.

Table I
Statistical analysis for L+OS.

Period 1990-2018	N	An	H
Mean	27.95	13.95	7.95
Standard deviation	23.1391	11.6896	6.4678
p - comparison with N	–	0.2	0.1033
p - comparison between An and H	–	–	0.2216

b) L+OS analysis (Fig. 4; Table II)

The first publications about L+OS were in 1980. The number of publications related to L+OS presented an increasing dynamic over time, for N and An and H, the

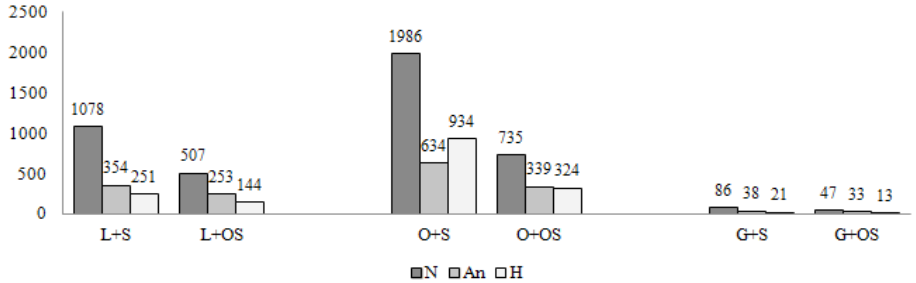

Fig. 2 - Comparative analysis of the keyword combinations chosen for S and OS, related to the Species filter.

highest number being in 2018 (53.7/an - N; 24.1/an - An; 22.6/an - H). Publications that included animals, although consistently slightly more numerous, were numerically close to those on human subjects. The differences between N-An, N-H, An-H were not significant.

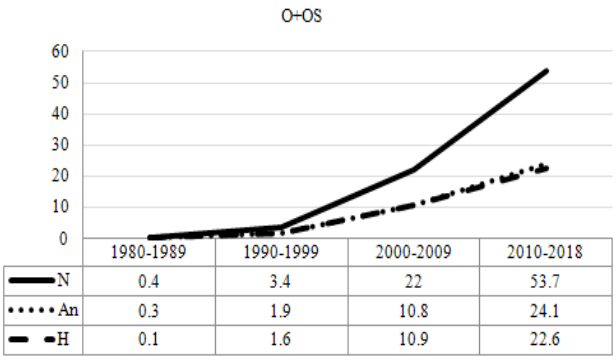

Fig. 4 - Dynamic analysis of N/Year for O+OS.

Table II
Statistical analysis for O+OS.

Period 1990-2018	N	An	H
Mean	31.8	14.84	14.08
Standard deviation	30.4744	13.9744	13.2661
p - comparison with N	–	0.1509	0.1433
p - comparison between An and H	–	–	0.4848

c) G+OS analysis (Fig. 5; Table III)

The first publications about G+OS were in 2000. The number of publications related to L+OS presented an increasing dynamic over time, both for N and for An and H, the highest number being in 2018 (4.1/an - N; 2.9/an - An; 1.3/an - H). Publications that included human subjects were consistently lower compared to those on animals. The differences between N-An, N-H, were not, but the An-H difference was significant (p=0.0454).

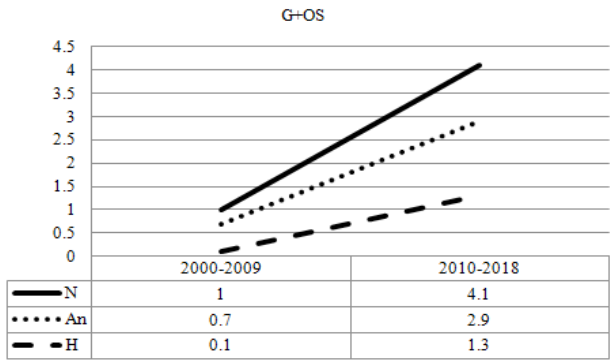

Fig. 5 – Dynamic analysis of N/Year for G+OS.

Table III
Statistical analysis for G+OS.

Period 1990-2018	N	An	H
Mean	3.4	2.4	0.93
Standard deviation	1.7454	1.2355	0.5906
p - comparison with N	–	0.1266	0.2492
p - comparison between An and H	–	–	0.0454

Discussion

The present article constitutes a continuation of previous researches of the authors, regarding the polyphenols (Jurcău, 2012) and antioxidants (Jurcău & Jurcău, 2013; Jurcău at al., 2019a: Jurcău at al., 2019b).

1. Comparative analysis of the total number of publications, for the chosen key word combinations related to Citrus. The fact that N for Citrus is very close to N for Citrus+S, for all three citrus categories chosen (L=1078, L+S=1053; O=1986, L+S=1963; G=86, G+ S=81), could be explained by the fact that citrus fruits are considered important in relation to stress. The significant number of publications for Citrus+OS denotes interest in the use of selected citrus fruits in the context of oxidative stress. Among the three citrus fruits selected, the greatest research interest was shown for O, both in combination with S (1963) and with OS (729), and the least for G (G+S=81, G+OS =43). This may lead to the idea that studies on G+S/G+OS are still recent for the two main types of stress, psychological and oxidative.

2. Comparative analysis of the keyword combinations chosen for S and OS, related to the Species filter. For L and G, both in combination with S and OS, the highest number of publications was for An (L+S=354, L+OS=253; G+S=38, G+OS=33). In contrast, in the case of O, for the O+S combination studies with human subjects predominated (934), and for O+, those with animals (324). It thus proves that studies with human subjects, although numerically close to those on animals, are still less interesting for research.

3. Analysis of keyword combinations between the three Citruses and OS, relative to the Species filter. The dynamic evolution of N/Year for all three citrus fruits selected in combination with SO, compared to the Species filter, was increasing, which proves that the interest in time related to these studies is important and in a continuous evolution. This fact could be explained by the fact that recently, the incidence of oxidative stress is increasing, hence the need for stress modulation and the evaluation of antioxidant resources, of which citrus fruits are a part.

4. Mechanism of action of citrus fruits in stress. Citrus fruits inhibit oxidative stress (Parhiz et al., 2015). They contain useful substances such as flavonoids. Thus, citroflavonoids provide antioxidant and antihemorrhagic protection (Singh et al., 2020), strengthen the vascular walls. Hesperidin is a citrus flavonoid that reduces stress-related damage by inhibiting oxidative stress, inflammation, and apoptosis, allows for the increase of protective enzymatic and non-enzymatic antioxidants (Maurya et al., 2018). Citrus essential oil can have beneficial effects on inflammation, inhibit the production of pro-inflammatory cytokines in induced oxidative stress (Samie et al., 2018) and increase resistance to physical and mental stress.

Conclusions

1. Interest in studies dealing with L+S/L+OS and O+S/O+OS was greater than research interest for G+S/G+OS .

2. Studies on the combination of citrus fruits and S were consistently more numerous, thus proving less interest in research related to L, O and G in relation to oxidative stress.

3. Publications for L, O and G, in combination with S and OS, although more numerous for animals, show that there is a growing interest in research involving human subjects.

4. The number of studies related to the three selected citrus fruits in combination with S and SO had an upward dynamic from the first publication until 2018, proving an increasing interest over time for these subjects.

Conflicts of interest

Nothing to declare.

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