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Comparison of antioxidant properties in foods from organic and conventional agriculture

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Abstract
Organic farming is a suitable production method both to safeguard the territory and to offer quality products to the local and international market.
Although high quality assurance requires a great deal of economic effort on the part of the consumer, organic products, after a slow start-up phase, are becoming increasingly popular in the food shopping sector, mainly in the most economically advanced areas (1).
Beyond the evident toxicological safety guaranteed by organic products, in recent years the scientific debate has addressed the problem of how much the overall nutritional intake, in protective molecules (e.g. antioxidants) is comparable with similar foods obtained through conventional agriculture. In particular, in this study a comparison was made between the content of antioxidant molecules, and relative overall antioxidant activity, in conventional and organic foods and vegetable juices and after processing (2).
The products under study come both from the LDO (Large Organized Distribution) and from crops of certain origin. In general, significant differences were observed in the various cases.

Keywords: antioxidant properties, organic, conventional agriculture

Introduction
In the context of proper nutrition there are continuous comparisons regarding which is the most correct diet in general or the most suitable for the different age groups. As known, a correct diet appears to be the main ally of growth in respect of the percentiles, the maintenance of the state of health, as well as the key in the prevention of chronic, acute and aging diseases. But the point is to define which, of all the proposals, reflects the right middle ground and whether the new food "offers" are more harmful than beneficial or vice versa [3-5].
The purpose of this study is the comparison of the different food proposals promoted in recent years to provide a general picture of the limits and advantages that each of these surely presents, especially as regards the content of antioxidants.
By determining the concentrations of polyphenols, carotenoids, anthocyanins and antioxidant capacity in general, it will be assessed whether the quality promised by food fashion is real or not and if the guidelines established by the Italian Ministry of Health are respected.
The analyzes carried out on organic food of controlled vegetal origin and on food for vegans represent a first step in the investigation of the antioxidant content, which can be further analyzed with more specific or different essays (DPPH, FRAP, TBARS, HPLC, etc.).
The samples include vegetables (salad, fennel, eggplant, pepper, tomato, beetroot, courgette), fruit (apricot, watermelon, strawberry, melon, peach, walnut peach), fruit juices (apricot, carrot, cranberry and pear juice) and vegan foods (soy and quinoa burger, courgettes burger, tofu and seitan).
The products were analyzed both raw and after cooking with the conventional techniques suggested by nutritionists and experts (steaming, grilling and boiling) to investigate the possible loss of the antioxidant component caused by these [5].

Materials and Methods
Instruments and sample preparation
The sampling was carried out by purchasing products of plant origin both from large organized distribution and in small local outlets and from specialized organic and vegan food outlets. Much of the fruit and vegetables purchased were grown in the Friuli Venezia Giulia region. The following tables show a list of the analyzed samples:

Table 1: List of analyzed foods

Origin	Samples
Non-organic vegetables	Carrots, cabbage, cucumber, fennel, salad, eggplant, tomato, beetroot, courgette
Non-organic fruit	Apricot, watermelon, strawberry, melon, peach, walnut peach
Non-organic fruit juices	Peach juice, apricot juice, pear juice
Organic vegetables	Carrot, salad, eggplant, yellow pepper, tomato, beetroot, courgette
Organic fruit	Apricot, watermelon, cherry, melon, peach, walnut peach
Organic fruit juices	Apricot juice, carrot juice, cranberry juice, pear juice
Vegan foods	Soy burger, quinoa burger and courgette, seitan, tofu

For the preparation of both raw and cooked samples and their extraction of the different components from the lipophilic and hydrophilic phases, the methods described in a previous study conducted by Calabretti *et al*., 2008 [6] were adopted. For this study, colorimetric assays were used to measure indices recognized by a vast literature as indicators of the antioxidant power and quality of the food product, such as IC50, ARP and TEAC [2-6]. Agilent Technologies' Cary 60 UV-VIS spectrophotometer was used for the colorimetric tests. The quantitative determination was carried out by means of calibration lines, constructed using concentration ranges suited to the content of the analyzed analytes.

Results and discussion Total polyphenol content

In Tables 2a – 2c the data regarding the total polyphenol content are compared. The data were obtained by using the Folin-Ciocalteu reagent test [7-9].

Table 2a: Total polyphenol content in commercial vegetables are expressed; the data refers to the average of three measurements ±SD

Samples	
Non-organic foods	**Polyphenol (mg/g)**
Boiled carrot	0,112 ±0,016
Raw carrot	0,380 ±0,038
Steamed carrot	0,232 ±0,010
Fresh Salad	2,600 ±0,173
Raw tomato	2,653 ±0,032
Beetroot	7,600 ±0,100
Boiled courgette	1,167 ±0,058
Raw courgette	1,267 ±0,058
Steamed courgette	1,000 ±0,100

Table 2b: Total polyphenol content in organic vegetables are expressed; the data refers to the average of three measurements ±SD

Organic foods	Polyphenol (mg/g)
Apricot	0,413 ±0,009
Watermelon	0,548 ±0,025
Boiled carrot	0,791 ±0,007
Raw carrot	0,06 ±0,020
Steamed carrot	0,838 ±0,010
Cherry	1,260 ±0,046
Salad	0,07 ±0,026
Steamed eggplant with peel	3,226 ±0,193
Raw eggplant with peel	2,361 ±0,007
Raw eggplant without peel	1,088 ±0,069
Raw eggplant peel	4,333 ±0,163
Melon	1,842 ±0,113
Raw yellow pepper	0,474 ±0,098
Steamed yellow pepper	1,303 ±0,244
Yellow nectarine peach	2,209 ±0,119
Nectarine	0,683 ±0,130
Raw tomato	0,882 ±0,044
Steamed red beetroots	9,113 ±0,119
Raw courgettes	0,62 ±0,060
Steamed courgettes	0,37 ±0,122
Organic fruit juices	Polyphenol (mg/g)
Apricot juice	0,44 ±0,042
Carrot juice	1,868 ±0,091
Blueberry juice	0,344 ±0,112
Pear juice	2,808 ±0,063
Peach juice	1,263 ±0,013

Table 2c: Total polyphenol content in vegan are expressed; the data refers to the average of three measurements ±SD

Foods for vegans	Polyphenol (mg/g)
Raw soy burger	0,898 ±0,131
Quinoa burger and grilled	0,650 ±0,0350
Raw Seitan	0,985 ±0,082
Tofu	1,196 ±0,10

In tables 2a - 2c the determination of the polyphenol content was used to evaluate the protective quality of the different foods. In fact, polyphenols are molecules that act by protecting the organism from oxidative processes, thus predisposing it to a better state of health. As highlighted, the total content of polyphenols in the foods analyzed varies both according to the transformation undergone (fresh, steamed, boiled, grilled, squeezed) and by origin. Some foods naturally have a high concentration of polyphenols (such as beetroots or peaches), mainly concentrated in the skin.
As far as the type of cooking is concerned, it can modify the polyphenol content both negatively, reducing the quantity due to water solubility and thermolability, and positively, making them more bioavailable. In the case of yellow pepper, for example, steaming caused the polyphenols to be "released", thus causing their concentration to almost tripled (0.474 mg / g in raw yellow pepper vs 1.303 mg / g).
The same effect was noted in the case of carrot and eggplant, while steaming courgettes the polyphenol content available. As evident, cooking is therefore a determining factor which substantially affects the overall content of polyphenols.
As for processed foods, in this case fruit juices, the richest in polyphenols are pear juice and carrot juice; these values are probably due to a high concentration of quercetin in the first case and of β- carotene in the second, resistant to technological treatments used in the production of juices.

Antioxidant activity

Antioxidant activity is the measure of the ability of a *substance* to counteract the action of the free radicals and can be expressed primarily through three indices.

1. The IC50 value identifies the concentration of analyte (antioxidant) necessary to inhibit 50% of the radical present in the ABTS solution used for the test;
2. The ARP index point out overall anti-radical power of each sample;
3. The TEAC index identifies the concentration of a solution of the sample under examination with the antioxidant capacity equivalent to that of the same concentration of a Trolox® solution [10-12].

The antioxidant power is therefore represented by a low IC50 value or by a high ARP value.

Table 3: Antioxidant power in "commercial" vegetables foods.

Vegetables	IC 50 (µg/g)	ARP
Carrot	56,79	0,017
Salad	4,74	0,210
Raw tomato	18,29	0,054
Raw courgettes	7,44	0,134
Boiled courgettes	442,59	0,002

Table 4: Antioxidant power in organic foods

Organic foods	IC 50 (µg/g) fase idrofila	ARP	IC 50 (µg/g) fase lipofila	ARP
Apricot	136,22	0,007	49,88	0,020
Watermelon	39,20	0,025	7,46	0,134
Raw carrot	7,80	0,128	7,30	0,136
Steamed carrot	5,06	0,197	73,40	0,013
Boiled carrot	190,15	0,005	1,25	0,800
Cherry	82,01	0,012	2,75	0,363
Salad	2,25	0,444	Nd	Nd
Raw eggplant with peel	158,60	0,006	Nd	Nd
Raw eggplant without peel	334,52	0,002	Nd	Nd
Steamed eggplant with peel	359,31	0,002	Nd	Nd
Eggplant peel	145,04	0,006	Nd	Nd
Melon	153,90	0,006	572,40	0,001
Raw yellow pepper	57,60	0,017	771,40	0,001
Steamed yellow pepper	50,88	0,019	112,03	0,008
Nectarine	48,84	0,020	668,85	0,001
Raw tomato	88,03	0,011	32,35	0,030
Steamed red beetroots	489,47	0,002	0,379	2,638
Raw courgettes	58,56	0,017	Nd	Nd
Steamed courgettes	49,22	0,020	Nd	Nd

Also in the case of the evaluation of the antioxidant capacity through the expression of the IC50 and ARP indices, the loss of antioxidants is evident following boiling and release, on the contrary, of these following steaming (see the data on organic carrots and courgettes).
However, the comparison of the two tables shows the greater antioxidant power of some plant foods of non-biological origin than those of biological origin. The values relating to the antioxidant power of tomatoes and courgettes, for example, have an important gap, which contrasts with the idea of a healthier organic product than non-organic.

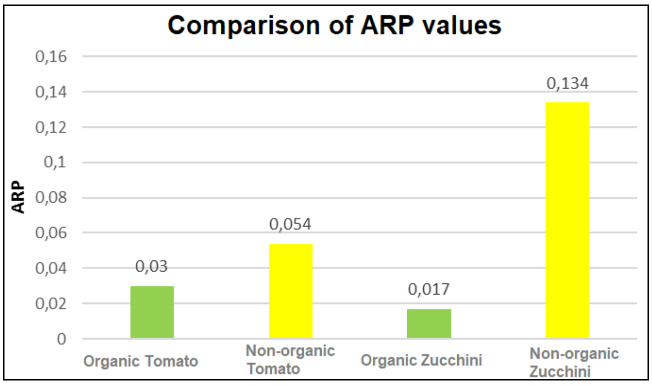

Fig 1: Comparative ARP values.

The evaluation of the antioxidant capacity, in the case of biological products, was performed both on the hydrophilic and on the lipophilic fraction
In the case of the tomato, for example, we find a lower IC50 relative to the lipophilic fraction, a value that demonstrates a greater concentration of antioxidant molecules in the fat matrix and that appears to be in line with what is stated in the scientific literature. As for organic fruit juices, the elements with greater antioxidant power were apricot juice and pear juice, which have relatively low IC 50 values. Finally, the data on vegan foods have highlighted the fact that in general the antioxidant power is almost zero; in fact, the respective ARP values border on zero.
Despite the fact that the tofu in particular had shown a considerable concentration of polyphenols, the overall antioxidant power is very low, probably because these polyphenols cannot be easily split from the matrix. This result demonstrates, for those people who adopt a vegan diet, the need to pay attention to this deficit and to introduce the use of supplements in the diet.

Table 5: Comparison of fruit juice and vegan food indices

Organic fruit juices	IC50 (µg/g)	ARP
Apricot juice	26,12	0,038
Carrot juice	168,20	0,005
Blueberry juice	110,25	0,009
Pear juice	194,31	0,005
Peach juice	88,85	0,011
Vegan foods	IC50 (µg/g)	ARP
Seitan	605,00	0,0016
Quinoa and courgette burger	550,85	0,0018
Soy burger	663,38	0,0015
Tofu	2791,13	0,0003

Evaluation of carotenoid content

The dosage of carotenoids showed higher values in processed foods after cooking. These molecules, in order to carry out their antioxidant activity, must be made bioavailable that is, freed from the matrix, as happens with some types of cooking.

Table 6: Carotenoid content in commercial and organic plant foods

Commercial vegetables	Carotenoids (mg/g)
Raw carrot	0,370±0,010
Steamed carrot	0,537±0,015
Raw tomato	1,453±0,050
Radish	0,210±0,010
Organic vegetables	Carotenoids (mg/g)
Apricot	0,213±0,015
Watermelon	0,031±0,011
Raw carrot	0,603±0,045
Steamed carrot	0,930±0,015
Boiled carrot	0,002±0,001
Melon	1,357±0,026
Raw yellow pepper	2,656±0,125
Steamed yellow pepper	2,456±0,050
Fishing	0,907±0,003
Nectarine	1,203±0,006
Raw tomato	0,132±0,003

The greater bioavailability of carotenoids, as seen, is made possible by mechanical and thermal treatment, as long as it is not boiling, which tends to deprive the matrix of antioxidant components, freeing them in the cooking water which in most cases is eliminated. The literature reports studies that prove that mechanical treatment can increase the bioavailability of these molecules [9] or vegetable foods of biological derivation, the interesting data is the difference in concentration between organic and non-organic raw tomato; once again, organic production with regard to the content of antioxidants compared to non-organic production is very poor.

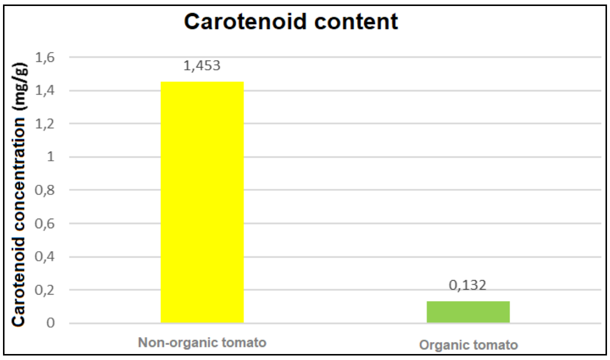

Fig 2: Comparison of carotenoid contents.

Evaluation of anthocyanin content

Anthocyanins are mainly found in plant products that show a purple color, of which these molecules are responsible. Their dosage produced the following results:

Table 7: Anthocyanin content in non-organic and biological foods

Non-organic food	Anthocyanin (mg/g)
Red radish	0,468
Beetroot	0,350
Organic food	Antociani (mg/g)
Cherry	0,067
Raw eggplant with peel	0,021
Raw eggplant without peel	0,0052
Eggplant peel	0,0575
Steamed eggplant	0,0070
Steamed red beetroots	0,0505
Blueberry juice	0,022

From these data it can be seen that steaming does not allow the anthocyanins to be freed and made more bioavailable, but on the contrary it causes almost a total loss. Furthermore, there is no substantial difference between fresh and processed food; in fact, the anthocyanin content in cranberry juice does not go far from that, for example, of raw eggplant with peel. Finally, as expected, most of these molecules are present in the skin of the plant food.

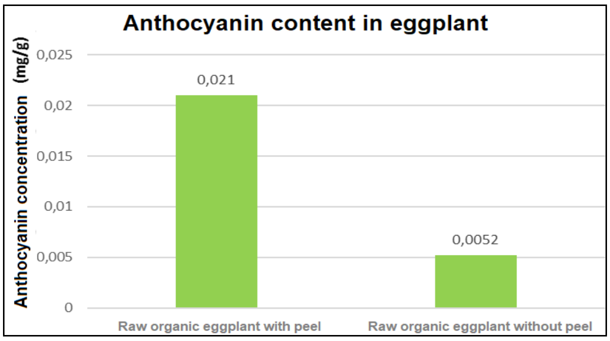

Fig 3: Content of anthocyanins in the organic eggplant with and without peel.

Conclusions

The result of this study suggests:

1. a preference for organic farming, not so much as generating quantitatively richer products than radical scavengers, but rather as guarantor of greater quality and protection of products and consumers from harmful chemical substances;
2. the integration of vitamins and antioxidants for adults who are loyal to vegan;
3. an in-depth investigation concerning the different categories of antioxidants through separative analytical techniques (extraction from powders with supercritical CO2, HPLC) and less subject to interference error;
4. A statistical survey on the applicability of the vegan diet to developing countries.

The study showed that the vegan diet is a delicate choice, which must however respect the values expressed in the LARN of a minimum consumption of 650 mg / day of polyphenols.

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