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Review Article

Why Indeed we have to Eat Quite a Lot of Vegetables and Fruit? What does this have to do with.... the Krebs Cycle?

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Abstract

Most people, including dietitians, consider fruit and vegetables as an important source of carbohydrates, but above all vitamins, microelements and antioxidants, as well as plant fiber. One should agree with this, although when we move on to quantitative data, there are many views highly debatable, even doubtful. Clarifying these doubts and providing a real picture of the role of vegetables, fruit, but also seeds and nuts is the main goal of this article.

The article indicates other reasons why we should eat a lot of vegetables and fruit, not necessarily raw [the case of sirtuins, nesfatin, capsaicin, but also homocysteine and their relationship with metabolism, health and diseases]. But the author also emphasizes the role of vegetables and fruit, and especially their juices, as sources of organic acids [actually their anions] being metabolites of the Krebs cycle and its non-enzymatic catalysts. As such, they accelerate combustion, which gives us enormous amounts of energy.

Keywords: *Nutrition; Vegetables; Fruit; Antioxidants; Vitamins; Metabolism; Krebs Cycle*

Main components [according % of dry mass]

But are they the most important, irreplaceable - for human beings?

Modern dietitians recommend using a balanced diet rich in vegetables and fruit [VF], often with the emphasis that they are to be eaten raw.

What, although important, in my opinion is not the main justification for the necessity of eating VF?

It is rather obvious that VF is an important source of carbohydrates - next to cereal products [bread, pasta, rice. groats] being the main source. The highest content of carbohydrate, i.e. sugars is contained in dry seeds of legumes [beans, peas 60 - 62%, lentils [57.5%], but also garlic [32.6%] [1] - for comparison, potatoes average 18.3% [compare white rice 78.9%, and wheat flour about 74%]. Of the fruit, banana has the most 23.5%, but of which 11.1% is sucrose. Grapes have about 17.6% [mainly glucose], and cherries, pears and black currants around 14.5% [mainly fructans and even free fructose]; other fruit similarly [7 - 14% of total carbohydrates].

But this high carbohydrate content does not seem to be one of the most important reasons why we should, and even more so, have to eat a lot of VF.

Glucose [practically the only end product of the digestion of carbohydrates - mainly starch - in the digestive tract] may in the liver arise from glycerol from fats and almost all [except leucine] amino acids [so-called gluconeogenesis]. So actually, theoretically you could not eat carbohydrates at all. However, I do not want to deal here with the issues of vegan and vegetarian diets, or even low carbohydrate diets [2].

Well, VF is not an essential source of fats and not only those containing mostly saturated fatty acids. Also, the content of "monounsaturated" fatty acids [MUFA], recently often praised by the official dietitians, is not high with just one exception: avocado 11.5% (See table 1) [1]. The same applies to polyunsaturated fatty acids [PUFA] necessary for humans (Also table 1) - here also avocados stand out [1.33%], although parsley root [0.27%] and strawberries [0.24%] have a lot of them, comparing to e.g. beef tenderloin [0.11%], skinless chicken breast [0.3%]. If we expand the scope of the article with nuts and seeds [after all, they are fruit, aren't they?], it will be quite different here: they are a very rich source of both MUFA and PUFA (Compare table 1).

	Component →		**PUFA [MUFA]**	**Dietary fiber**	**Vit. A**	**Vit. D**	**Vit. E**	**Vit. B1**	**Vit. B2**	**Vit. PP**	**Vit. C**	**Vit. B2**	**Folates**	**Vit. B6**
	Units per 100g → of edible parts / **Product ↓**		**g**	g	µg	µg	**mg**	µg	**mg**	**mg**	**mg**	µg	µg	**mg**
1	Animal	Mutton shoulder	**1,21 [9,57]**	0	**53**	**0,3**	**0,6**	**140**	0,19	**4,5**	0	-	-	-
2		Pork shoulder	**1,50 [10,94]**	0	0	**0,7**	0,4	**599**	**0,27**	**3,06**	0	0,7	3	**0,3**
3		Veal liver	0,43 [0,76]	0	**21920**	**0,33**	0,24	**280**	**2,61**	**15**	**35**	**60**	**240**	**0,9**
4		Beef liver	0,53 [0,45]	0	**14400**	**1,1**	**0,67**	**260**	**3,33**	**13,7**	**31**	**110**	**330**	**0,84**
5		Chicken liver	0,99 [1,54]	0	**9304**	**0,2**	0,25	**360**	**2,7**	**10,2**	**23**	**35**	**590**	**0,4**
6		Beef tenderloin	0,11 [1,51]	0	11	0,4	0,2	79	**0,26**	**5,54**	0	1,4	10	**0,25**
7		Chicken breast-without skin	0,3 [0,3]	0	6	0	0,3	90	0,15	**12,44**	0	0,4	12	**0,55**
8		Pork hearts	0,14 [1,24]	0	8	0,7	0,41	430	**1,24**	**6**	**6**	2,7	4	**0,43**
9		Pork kidneys	0,67 [1,2]	0	36	1	0,41	580	**1,74**	**9,8**	**13**	17	**45**	-
10		Fresh sardines	**1,60 [2,50]**	0	20	**11**	0,29	20	**0,22**	**6,7**	0	-	-	-
11		Smoked salmon	**1,94 [3,43]**	0	30	**13**	**1,3**	**230**	0,1	**7**	0	-	26	**0,68**
12	Vegetables	Onions	0,17 [0,04]	1,7	2	0	0,12	30	0,03	0,2	**6**	0	17	0,1
13		Parsley-root	0,27 [0,03]	4,2	5	0	2,01	100	0,09	2	**45**	0	180	**0,23**
14		Red pepper	0,17 [0,01]	**2**	**528**	0	**2,9**	40	0,12	1,6	**144**	0	**52**	**0,45**
15		Tomatoes	0,10 [0,10	**2,7**	107	0	**1,22**	64	0,04	1	**23**	0	**39**	0,15
16		Asparagus	0,11 [0,0]	**2,1**	101	0	**1,8**	**142**	0,17	1,25	**26**	0	**150**	0,06
17		Potatoes [average]	0,06 [0,0]	1,5	1	0	0,05	87	0,04	1,46	**14**	0	20	**0,3**
18		Avocado	**1,33 [11,51]**	**3,3**	7	0	**1,3**	110	0,12	1,9	**8**	0	**62**	**0,28**

19	Fruits	Bananas	0, 0,06 [0,03]	1,7	8	0	0,27	40	0,1	0,5	**9**	0	22	**0,36**
20		Apples	0,09 [0,01]	2	4	0	0,49	34	0,03	0,17	**9,2**	0	6	0,03
21		Oranges	0,04 [0,04]	1,9	19	0	0,19	80	0,03	0,2	49	0	**30**	0,1
22		Melon	0,03 [0,01]	1	183	0	0,1	40	0,02	0,6	**20**	0	**30**	0,12
23		Strawberries	0,24 [0,07]	1,8	2	0	0,12	28	0,06	0,28	**66**	0	17	0,06
24		Grapes	0,06 [0,01]	1,5	3	0	0,7	60	0,04	0,2	**5,4**	0	6	0,08
25	Nuts	Almonds	**10,90 [33,65]**	**12,9**	0	0	**24**	**210**	**0,78**	**3,4**	**5,6**	0	**96**	0,11
26		Peanuts	**14,58 [22,91]**	**7,3**	0	0	**9,1**	**660**	0,13	**14,2**	0	0	**110**	**0,3**
27		Pumpkin seeds	**20,88 [14,19]**	**5,3**	38	0	**26**	**210**	**0,32**	1,7	0	0	**60**	0,1
28	Various-plant	Cocoa 16 % powder	0,69 **[7,24]**	**5,7**	2	0	0,37	110	**0,46**	2,4	0	0	**38**	0,07
29		White rice	0,26 [0,18]	**2,4**	0	0	0,33	52	0,03	0,82	0	0	29	0,17
30		Wheat flour type 500	0,74 [0,15]	**2,3**	0	0	0,4	111	0,05	0,93	0	0	**54**	0,02
		Bold text: → for concentration >>> red < dark violet	> 1 [2] > 9 [10] < 0,2 [0,5]	> 2 >5 =0	> 50 > 500 < 3	> 0,2 > 10 =0	> 0,6 > 9 < 0,2	> 140 > 250 < 40	> 0,2 > 2 < 0,1	> 3 > 10 < 1	> 5 > 40 = 0	> 30 =0	> 30 > 100 = 0	> 0,2 >> >0,6 < 0,1

***Table 1:** Contents of main vitamins [as well as poly and monounsaturated fatty acids and dietary fiber] in: A: some animal products [including liver], B: vegetables, C: fruit, D: nuts and seeds; also some various products.*

And what about protein? First of all, it is usually very, very scant; if there is a bit more according to the given statements, this applies to dry seeds - of course after soaking and cooking, i.e. in a ready-to-eat dish, this content is 3 - 6 times lower.

Some examples: dry seeds: white bean 21.4%, soybean 34.3%; as for the rest of the vegetables, the least is in cucumber ["water alone"] 0.7%, and the most in green peas 6.4%; the rest of the vegetables on average 2 - 2.5% [meat from 15 to 25%]; fruit usually even less [0.4 - 1%], but blackcurrant 1.3%, and again the champion: avocados 2% [1].

But it is not enough that vegetables and fruit contain little and very little total protein, this protein is of low quality. These proteins either do not contain one or two amino acids necessary for humans or contain all these type amino acids, but in very small amounts, in any case, smaller than in proteins from meat and other animal products. These essential exogenous amino acids are not produced in the human body. Without them, there is a gradual "dying off", actually even like kwashiorkor, or in any case a negative nitrogen balance with its consequences.

Perhaps the only known exception is/are protein/s of quinoa [Peruvian rice] which was claimed to contain total protein in which essential amino acids are present in percentages and proportions similar to those of animal proteins. But when we look at the figures, quinoa does not look so great, but it stands out from vegetable protein sources. The amino acids necessary for quinoa are only 36.2% of total protein, while in chicken breast 51% [3]. Quinoa [Q] protein contains nearly two times less lysine than chicken breast [C] protein [Q/C = 0.55]; only the percentage of tryptophan and methionine [with cysteine] is almost the same [% Q/C 0.92 and 0.95, respectively] Note: % of [methionine + cysteine] and % of [phenylalanine + tyrosine] is very misleading. Although cysteine is formed in the body from methionine and tyrosine from phenylalanine, what if there is the relatively high content of the sum values given above, but the content of methionine and phenylalanine themselves is close to zero?

The content of essential amino acids in VF proteins is low, and for a number of them close to zero. It is better in the case of cereal seeds and legumes including soybean and quinoa. However, to cover the daily requirements [RDA] for essential amino acids, you should eat about 150g of chicken meat, about 100g of beef tenderloin, but probably about 1100g of quinoa, 400g of soybean seeds, about 1 kg of tofu ["cottage cheese" made from the so-called soy milk] and about 2 kg of rice [of course, I'm talking about ready-to-eat products, not about raw beans].

The picture can be depressing for vegetarians, especially vegans. But I think veganism [and even more semi-vegetarianism] is "acceptable, and does not have to lead to health problems, in tropical countries [Thailand, Mexico, India and closer to the equator [Brazil]. There is such lush vegetation [and frequent crops], and especially enormous biodiversity [with lots of fruit, vegetables, seeds, roots difficult for Europeans to imagine]. This means that we use there a mixture of products being themselves "nutritionally poor" that in total this mixture [as in the daytime to week] becomes fully sufficient. I will not deal with veganism any more in this work.

I will not deal with microelements [let alone macroelements] and fibres [1], because there's a lot of data on it.

In further parts of text I will present four reasons [sets of reasons] why we really have to eat quite a lot of VF [and additionally nuts and seeds]. I will elaborate on them. They concern: 1. antioxidants; 2. vitamins including their role in homocysteine metabolism; 3. some bioregulators as capsaicin; 4. metabolites of Krebs cycle [!]. All of them are abundant in Mediterranean diet [4,5].

Antioxidants

Oxidative stress might be explained as the lack of equilibrium between formation/inflow of reactive oxygen species (ROS) and antioxidative substances [and enzymes] in human body. Psychophysiological ["normal"] stress might somehow facilitate formation of ROS. But on the other hand, ROS come from oxidative stress might cause a drop of immunity and so result in increased susceptibility to "normal" stress [6].

The ubiquitous and life-giving oxygen is the source of ROS owing to the cascade of reactions forming consecutively superoxide anion radicals O_2^-●, H_2O_2 and finally hydroxyl radical ●OH [7,8]. The latter is the killer indeed as it modifies - in fact makes damage to both numerous proteins and fatty acid chains of lipids in biological membranes. Thus both enzyme driven metabolism and transport might be heavily affected.

Antioxidants neutralize radicals so ROS [but parallelly they "die"]. Thus, the antioxidants present in the diet mostly in fruit, legumes and spices play the protective role first of all. One should mention the following most important antioxidants: (soluble): vitamin C, uric acid, resveratrol, allantoin, glutathione, bilirubin, anthocyanins, flavonoids, selenium and copper ions [9].

There are also antioxidants soluble in lipids thus protecting membranes: vitamins E, A, K, D, steroid hormones, coenzyme Q_{10}, β-carotene, lycopene and lutein [9].

Ghavipour., *et al.* [10] proved that regular consumption of tomato juice alleviates oxidative stress of overweight and obese women.

Telegawkar., *et al.* [11] proved that the antioxidative potential of serum - i.e. its ability to neutralize some ROS added to serum sample with parallelly present both hydrophilic and lipophilic antioxidants - is correlated with a daily intake of antioxidants.

Everyday supplementation with omega-3-ω-PUFA, oleic acid, folic acid, vitamins E and B_6 resulted in significant elongation of the pain-free run distance of men with cardiovascular diseases [12]. The shortening of leukocyte telomeres during strong psychological stress - most probably owing to ROS - was shown by Wójcicki., *et al* [13]. But very recently Zhou., *et al.* [14] proved that legumes, nuts, seeds and fish evidently protect against shortening of leukocyte telomeres (but sweetened fizzy drinks.... act inversely).

Many diseases are somehow correlated with oxidative stress. Let us mention: neoplasms, Parkinson and Alzheimer's diseases, schizophrenia, asthma, diabetes, Down syndrome, coronary disease, infarct, stroke [9].

Actually, there were no hints on effects on antioxidants on pain level and frequency.

We found [15] that:

1. Higher daily intake of food antioxidants (DIFA) [16] infers/results in lowering of stress level; so is with the frequency of pain.
2. Persons with higher DIFA or simply consuming more antioxidants are longer and more frequently physically active.

Vitamins

Table 1 is selected from the literature data on the content of the most important vitamins, PUFA MUFA and dietary fibers. The data [1] in table 1 shows that:

1. Indeed the liver is a much richer source of most vitamins than other animal products [compare items marked in red], not to mention already about VF [compare items marked dark purple].
2. Nuts and seeds [here pumpkin seeds] have a lot of vitamin E, but also [especially peanuts] thiamine [vitamin B1]. But the content of other vitamins is also quite significant, and in peanuts high for niacin [vitamin PP] and folates.
3. Vegetables and fruit generally have a low vitamin content. Exceptions are:
    a. Vitamin C [in animal products occurs only in the liver], which is especially high in red peppers, tomatoes, strawberries and parsley root, as well as in parsley and black currant [Not shown in table 1].
    b. Folate, especially in parsley root, asparagus, but also broccoli, Brussels sprouts, kale, parsley leaves, spinach (Not shown in table 1); there is never a high folate content in fruit, and only for avocados, oranges and kiwi expressive amounts might be found (here: not shown in table 1). The level of folate is also very high in the liver, even higher than in asparagus. In other meats, folate levels are definitely lower than in vegetables, and even in fruit [it is at the same level as in apples and grapes].
4. Quite especially it is with a vitamin B6 [pyridoxal]. Because here is very low B6 content in asparagus and all fruit except bananas [but in parsley root, red pepper, avocado and potatoes, vitamin B6 level is already comparable as in meat].
5. Vitamin D is not found in vegetables and fruit; it is in the liver, but especially in marine fish [but not in hake and pollock], but not freshwater ones [maybe except carp].
6. Vitamin B_{12} is completely absent in vegetables, fruit and nuts, seeds and grains.

So, generally much more [sometimes incomparably more] vitamins especially soluble in water [group B consisting of more than 12 vitamins] are located in meat [so lamb, mutton, beef, poultry, fish, but most in liver]. Why?! It is pretty obvious! Vitamins are crucial for us because.... they are coenzymes [or their main parts] for thousands of enzymes. So, they must be located in tissues containing a lot of protein [enzymes are proteins!] in which a very intense metabolism takes place. So, they are found in liver [kidneys, hearts, brain...] but in muscles [Meat] either. Hardly so in the plant material [fruit, vegetables] with their more than 90% of water.

The best examples of relation: vitamin → sometimes intermediate form → final coenzyme are following [17]:

1. Pantothenic acid → pantetheine → coenzyme A.

2. Nicotinic acid [niacin; vit. PP] → nicotinamide [sometimes name niacin is also applied] → nicotinamide mononucleotide [NMN] → nicotinamide adenine dinucleotide [NAD] or its phosphate NADP.

3. Riboflavin [vit. B2] → flavin mononucleotide [FMN] → flavin adenine dinucleotide [FAD].

Well, for fat soluble vitamins [A, D, E, K] their role as coenzymes was not recognized yet. However, all of them bind to transporting proteins which not only take part in their transport as the chaperons and signalling factors [18]. They evidently play role in reactions catalysed with enzymes [participation of some cellular retinal binding proteins [CRALBP] in retinal reactions, crucial for vision processes [19].

It should be emphasized that, although cooking [including decoction casting], frying and baking reduce the vitamin content, practically never losses reach 50%, but for many vitamins do not exceed 20%. The exception is vitamin C, for which cooking [with pouring decoction] losses are about 75%. Folates can lose over 50 - 55%, so you can actually eat better raw. But the loss of other vitamins is 20 - 30%; when we make compote, we do not pour out the decoction and the loss can be even smaller [1].

Vitamins [this applies to almost all of them] can occur in at least three forms: a. “free” vitamins; b. whole coenzymes with vitamin c. the whole proteins/enzymes with vitamin in. And now it can happen that during “culinary treatment” form c is destroyed, whereas forms a and b are not. Form b may also fall apart, while the form a still does not change [17].

There are numerous signals about high liver contamination with exogenous poisons, especially “heavy metals”. But look: the liver has been - in millions of years of evolution - adapted for detoxication, and similarly the whole body was adapted to bind heavy metal ions. Here it should be mentioned that heavy metal ion binding proteins metallothioneins [MT] [20] are found in all tissues: MT-I and MT-II mainly in the liver and kidneys, and MT-III and MT-IV especially in the central nervous system [21,22]. MT are also involved in a fight with ROS [something as antioxidants] [23].

Vitamins, including fruit and vegetables, are involved in a multitude of processes, as is known from biochemistry and clinical biochemistry textbooks. Therefore, I will mention only the participation of vitamins in homocysteine metabolism. Homocysteine is the so-called “21st century cholesterol” [24]” Its high concentration is an independent risk factor for the development of atherosclerosis, coronary artery disease, all cardiovascular disorders, but also diseases of the nervous system and many other diseases. But why? After all, homocysteine [Hcy] is an amino acid, but not a building block for proteins, which must be formed from exogenous methionine on the way to the formation of another important amino acid cysteine, followed by a very important glutathione. Why is the elevated level of Hcy dangerous [25]? Because in all Hcy cells, the HCY ring anhydride (homocysteine thiolactone [Hcy-TL]) can be formed form high energy compound, and also extremely easy coming out into the plasma. This Hcy-TL is the real killer! Why? Because it modifies a lot of proteins [both in cells as well as in blood: plasma and erythrocytes either] thus deprives them of biological activity. What is even worse, such modified proteins are antigens in autoimmunological processes! it is especially dangerous if there is elevated level of Hcy [25,26].

This killer [Hcy-TL] reacts with proteins through a mechanism that involves homocysteinylation of side amine group of lysine protein residues. Homocysteinylation leads to protein damage/inactivation and autoimmunity. this is the real cause of endothelial destruction, even "puncture", atherosclerosis, heart attacks and congestion [25]!! Not just cholesterol! By the way, a calcium-dependent homocysteine thiolactonase, closely associated with HDL in human serum, can prevent protein damage by detoxifying thiolactone [just hydrolysing it] [26,27]. This is a real mechanism to explain the beneficial role of so-called good cholesterol [HDL] in the human body!!

However, to prevent a significant increase in the level of homocysteine in our body we must eat - in the form of dishes or possibly supplements - much more of a full set of vitamins than prescribed by official medicine: not only folic acid [folates] and vitamin B6 but also B12, B1, B2, PP pantothenic acid, biotin and lipoic acid [28]. They facilitate the transition from homocysteine to methionine, cysteine, glutathione. In this way these vitamins protect us from potentially toxic [high homocysteine] effects that I have discussed. Of course the beneficial role of folate especially [almost exclusively] rich in vegetables [and fruit] is crucial!

Some additional important substances

Additional reasons why we should eat quite a lot of fruit and vegetables:

1. Activating sirtuin with resveratrol present in grapes and some other fruit and abundant in red wine [29].

2. Activating nesfatin-1 [30] with some not yet identified components present in Mediterranean Diet - most probably capsaicin [31] from red pepper.

Sirtuins are a class of proteins that possess either mono-ADP-ribosyltransferase, or deacylase activity [or any other activity modifying proteins especially those bound to DNA in chromatin of cell nuclei] so causing an increase of gene expression-in all living creatures. Sirtuins have been implicated to play role in aging, apoptosis [programmed cell death], inflammation and stress resistance [32].

Sirtuin activity is inhibited by nicotinamide. Thus vitamin PP is one of first examples of the direct effect of vitamins on gene expression [33]. It binds to a specific receptor site, so it is a key for development of new drugs to treat degenerative diseases such as cancer, diabetes and atherosclerosis. Resveratrol, a possible sirtuin SIRT1 activator, can reproduce the effects of exercise and caloric restriction such as lowered blood pressure, sugar levels, and metabolic rate [29,30].

Nesfatin-1 is a peptide secreted by peripheral tissues, central and peripheral nervous system. It is involved in the regulation of energy homeostasis related with food regulation and water intake. Nesfatin-1 can pass through the blood-brain barrier in both directions. It suppresses feeding independently from the leptin pathway and increases insulin secretion from pancreatic beta islet cells.

But look on beneficial effects of capsaicin - substance present in high concentration in red and chili pepper - responsible for their spicy taste. Nesfatin-1 is a peptide decreasing appetite [so called anorexigenic] but this action is attenuated by pre-treatment with capsaicin TRPV1 receptor inhibitor capsazepine. So, it looks like that action of nesfatin-1 might be via effects of capsaicin. So, the main "actor" is capsaicin [31]!

Capsaicin is involved in thermogenesis, lipid metabolism, the inflammatory response, and oxidative stress. These effects of capsaicin reduce adipogenesis, alleviate insulin resistance, ameliorate vascular dysfunction and regulate glucose homeostasis. These pathophysiologic processes are responsible for the pathogenesis of cardiometabolic diseases, such as obesity, hypertension, dyslipidaemia, diabetes and atherosclerosis. Capsaicin plays a potential role in cardiometabolic protection through the activation of its receptor [TRPV1] in different target organs or tissues [32].

Krebs cycle metabolites as its nonenzymatic catalysts

Note that from all the main nutrients, i.e. carbohydrates, such as starch, glucose [so sucrose], all fats, so fatty acids, and protein amino acids during metabolism one common metabolite is formed!! It is so called acetyl coenzyme A [17].

It in turn enters the Krebs cycle [KC], and so it (and thus everything practically what we eat) is burned to carbon dioxide and water - giving us the energy to live. Why?!:

In every cyclic tour of KC two molecules of CO_2 are formed. But what is even more important four dehydrogenases - of KC - break away four times a pair of hydrogen atoms and transfer them into coenzyme of dehydrogenase [mostly so called NAD-containing vitamin PP - and thus reduced form NADH2 is formed: $NAD + XH_2 \rightarrow NADH_2 + X$]; once FAD [with vitamin B2 in] is accepting 2H thus forming $FADH_2$.

Thereafter hydrogen atoms [H+ ions i.e. protons and electrons] move through so called electron transfer chain on oxygen molecules O_2. So water is formed: [$2\ NADH_2 + O_2 \rightarrow 2\ NAD + 2\ H_2O$].

Then an enormous amount of energy [55 kcal/mole of water made] is liberated but about half of it is accumulated in form of ATP i.e. the general energy carrier of our body [high energy compound].

Then the acceleration of KC means the increase in the supply of hydrogen atoms (H^+ protons and electrons) to oxygen in the mitochondria (i.e. in cell power plants), and thus a relative increase in oxygen consumption in the so-called respiratory chain, and therefore acceleration of burning and increasing the amount of the most important high-energy compound of living organisms i.e. ATP.

Summary reaction of KC [with slight simplifications in the symbols] is the following one: Acetyl Coenzyme A + $2\ H_2O$ + 3 NAD + FAD + GDP +$P_i \rightarrow$ CoA + $2\ CO_2$ + $3\ NADH_2$ + $FADH_2$ + GTP + H_2O.

But look the "first" reaction of KC is Acetyl Coenzyme A + oxaloacetate + $H_2O \rightarrow$ citrate + CoA.

And in the next reactions in turn arise: isocitrate, α-oxoglutarate, succinyl Co A, succinate, fumarate, malate and oxaloacetate and the cycle begins the next tour, etc, etc. Anions [marked as bold] are dissociated forms of organic dicarboxylic or tricarboxylic [citrate] acids. So, it means that one could say that metabolites of KC are exclusively those organic acids: oxaloacetic, citric, malic, succinic or fumaric acids. Quite a lot of those acids exists in VF - so in the juices made from them [like apple, orange or tomato juices]. Well, they are largely responsible for smell and taste of VF. And that alone would be one of the main justifications for having to eat VF.

But much more important is that acids [anions] listed here are indeed not just metabolites of such a crucial process as KC but its nonenzymatic catalysts [NC so totally KCNC], as I mentioned before! Why? This is pretty obvious. They are indispensable for particular reactions of KC, so for KC as a whole, but they are neither substrates nor products of KC summary reaction! So, they must to be nonenzymatic catalysts of summary reaction of KC [KCNC]! Their bigger concentration apparently increases the velocity of KC as a whole thus arising amount of O_2 taken thus arising amount of ATP being formed in an unit of time!

I am not the author of this revelation, which is no longer a hypothesis - it is a fact! It was thought by the discoverer of KC Sir Hans Krebs long time ago [34], as you can also read in the wonderful, though today seeming somewhat old-fashioned Baldwin's "Dynamic biochemistry". The addition of these acids to the pigeon's breast muscle homogenate increased [in Sir Krebs experiments] the manometric amount of oxygen several dozen times, while the addition of e.g. tartaric or lactic acid did not give this effect [34]. This was the main argument for Krebs to propose the concept and course of the KC.

So, it is certainly to be assumed that one of the most important reasons for consuming large amounts of VF is that they provide KCNC!

It would seem that this should be widely known for a long time. But for unknown reasons it is not and in scientific papers it is not stated [zero at PubMed].

Of course, it is now emphasized that ATP is mainly regulated by so-called energy charge, and more generally by the ratio of ADP/ATP concentrations, and also that in the chain [and thus in the cycle] the reaction rate of the entire chain/cycle depends on the speed of the "limiting step" i.e. the slowest one. And indeed high concentration of ATP as an allosteric inhibitor inhibits cycle as a whole, because it inhibits citrate synthase and α-oxoglutarate dehydrogenase complex [35] while ADP is the opposite, because it is an allosteric activator of isocitrate dehydrogenase [22]. But this does not completely contradict the huge role of the elevated concentration of these acids as KCNC [36]. Likewise, regardless of which stage of the cycle is the bottleneck, the increase in the concentration of these KCNCs will still increase the KC rate.

And now I just have to prove that there is a lot of KCNC in VF and juices consumed and finally that they are quickly absorbed into the blood [they do not have to be digested, have they?] and into the tissues [even into the brain]. There are a lot of them, and sometimes very much. And so in vegetables: citric acid is the most common, especially in celery root [607 mg per 100 g wet mass - FW - i.e. 0.6%] - that is 22 times more than vitamin C [37]. But also a lot of citric acid [actually citrate] is in parsley [407 still in the same units], dill [299] or carrot [110]. But there are other KCNCs there. Sometimes, some are missing: most often there are no detectable amounts of malic acid [although there is as much as 818 mg/100g FW in a dill; low is fumaric acid, although in a dill 42 the same units. Succinic acid is rather low, although in garlic 185, and in celery root up to 843 [37]. In tomatoes there is citric acid 0.78% FW, and fumaric acid up to 1.43% [38].

Look, there is no problem that some KCNC are lacking. The other are abundant and in our cells one goes into the other and so on and so on.

Generally [a bit] less KCNC is in the fruit: 3.67 - 8.66‰ in sweet cherry [39]; and in apples: malic acid 0.51 - 7.56%, citric acid 0.19 - 2.59% and fumaric acid 0.09 - 5.2% [40].

In fresh apple juice there is 0.21% citric acid [Ci], and only 0.08% malic acid [Ma]; in orange juice 0.05% Ma and 0.53% Ci; while in lemon juice 1.11% [11,1%] Ma, and as much as 5.77% Ci i.e. 57.7% [41] [*Nomen omen*].

But more importantly, it turned out that there are numerous proteins specifically transporting organic acids in the human body, including KCNC di- and tricarboxylic acids [42,43]. In our brain, of course, these KCNC arise as a result of metabolism from glucose or amino acids, but still Oldendorf [44] showed that malic and citric acid can also enter the brain passing the blood-brain barrier [although, as having large negative charge, they pass there much harder than short fatty acids].

Why can juices be the preferred source for KCNC here? Due to the "concentration of ingredients" - we all know how much oranges you need to use to get a glass of freshly squeezed juice.

I will not discuss here fake stories about weight gain, acidification of the body, the progress of caries supposedly caused by drinking juices [maybe we should mention one paper [45], but it stresses sugar content which anyway could be burned in half an hour].

So, in fact only vegetables and fruit consumed (first of all for breakfast), especially in the form of juices - not only orange one - give a real increase in our strength in a short time (10 - 30 minutes after breakfast). All other breakfast ingredients will also "give energy", but in fact only a few hours past breakfast, because their content must first undergo a long digestion [2 - 6 hours] process in our digestive tract before final digestion products get into the cells and burn [with the Krebs cycle].

So, what do we burn since breakfast, with the obligatory as in England [but already in all Western Europe] orange or grapefruit juice? After all, not those KCNC [although they will eventually burn, but that's another matter]? We just "burn ourselves", i.e. spare fats from our adipocytes, small amounts of simple sugars from breakfast and amino acids from proteins destroyed by ROS radicals [although "antioxidants fight them"]. After all, each protein has a different "sensitivity to destruction", and therefore a biological lifetime [half-life T1/2]. There are some of them [e.g. ornithine decarboxylase that during the day have to "renew" [die and be synthesized again] up to 20 times, and maybe several hundred times [46] [although the average T1/2 is said to be about 3 - 4 days]. The myth is that only a person eating too little carbohydrates burns protein!

Whatever we burn from an early English breakfast to lunch [that I don't mention anything about coffee around 10.30 a.m.] VF and juices [unsweetened] are accelerating it anyway.

And now, do these KCNCs have to come from VF?

No, they can arise from the metabolism of glucose, glycerol and most amino acids. But why spend it on it? Better let them be used for the synthesis of antibodies or [glucose] for brain work.

Conclusion

Summarizing: why - we must eat fruit and vegetables? Because they contain:

1. A lot of antioxidants
2. A lot of ONLY TWO - three very important vitamins i.e. vitamin C and folic acid (maybe provitamin A should be included); the general view that they are the source of ALL vitamins is the myth!!
3. A lot of fibers, mostly cellulose
4. Organic acids, mostly the metabolites of Krebs cycle, being its strong nonenzymatic catalysts!!! So, they accelerate combustion, thus accelerating the release of energy necessary for life.

   Additionally, because:

5. Activating of sirtuin with resveratrol present in grapes and some other fruit and abundant in red wine
6. Activating nestin-1 with some not yet identified components present in the Mediterranean Diet, most probable capsaicin from the red pepper.

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