# The development and outcomes of the COVID-19 disease correlate with the type of nutrition

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**Summary**

***Aim***. Analyze the role of diet in the process of infection with the SARS-CoV-2 coronavirus and identify factors that correlate with a decrease in the pathogenic consequences of the COVID-19 disease.

***Materials and methods***. The information and data required for this review were found in scientific publications and the media available on the Internet, as well as obtained from statistical databases using specific keywords, both for a single tag, and in various combinations of them. Statistical samples were managed from sources and facts available on the Internet.

***Results and discussion***. The relationship between nutritional factors and the impact of the 15-month COVID-19 pandemic in different regions was investigated using various available statistics for five continents and 47 countries. A clear relationship was found between the prevalence of the SARS-CoV-2 epidemic and the amount of food consumed, with correlations in the negative range r = -0.98 and r = -0.66 for plant proteins and with a correlation coefficient r = 0.92 for animal proteins. Also, excessive sugar consumption increases the severity of COVID-19 with correlation coefficients in the range of r = 0.99-0.72.

***Conclusions***. Quantitative analysis of statistical data and an assessment of nutritional factors during the development of a 15-month pandemic in various regions showed that the severity of the infectious process of the SARS-CoV-2 virus and the COVID-19 disease was aggravated by excessive consumption of sugar, fat and total protein. The number of people infected with the virus or deaths from COVID-19 per 100,000 inhabitants was radically lower in regions where more plant foods were consumed than products of animal origin.

KEYWORDS: coronavirus SARS-CoV-2; diet; COVID-19 pandemic; epidemic; pathogenesis; risk factors

Conflict of interest: The author declares that she has no commercial or non-profit associations that could cause a conflict of interest in connection with the published manuscript.

Abbreviations: WHO -World Health Organization, SARS - severe acute respiratory syndrome, RPr - rate of prevalence, IFR - infection fatality rate, NA - Northern America, GDP - Gross Domestic Product per capita, CFR - case fatality rate, ACE - angiotensin-converting enzyme.

# Развитие и последствия болезни COVID-19 коррелируют с типом питания

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**Резюме**

***Цель***. Проанализировать роль диеты для эпидемиологических показателей коронавируса SARS-CoV-2 и выявить факторы, коррелирующие со снижением тяжести последствий от болезни COVID-19 в разных регионах.

***Материалы и методы***. Информация и данные, необходимые для этого обзора, были найдены в научных публикациях и средствах массовой информации, доступных в Интернете, а также получены из баз статистических данных, с использованием определенных ключевых слов для одного тега или в различных их комбинациях. Статистические выборки были сформированы из источников и фактов, доступных в Интернете.

***Результаты и обсуждение***. Связь между факторами питания и последствиеми 15-месячной пандемии COVID-19 в разных регионах была изучена с использованием множества доступных статистических данных для пяти континентов и 47 стран. Была обнаружена четкая взаимосвязь между патогенностью эпидемии SARS-CoV-2 и количеством потребляемой пищи с корреляциями в отрицательном диапазоне r = -0,98 и r = -0,66 для растительных белков и с коэффициентом корреляции r = 0,92 для белков животного происхождения. Также чрезмерное потребление сахара увеличивает тяжесть COVID-19 с коэффициентами корреляции в диапазоне r = 0,99-0,72.

***Выводы***. Количественный анализ статистических данных и оценка факторов питания при развитии 15-месячной пандемии в различных регионах показали, что тяжесть инфекционного процесса вируса SARS-CoV-2 и заболевания COVID-19 усугублялась чрезмерным потреблением сахара, жиров и общего белка. Число инфицированных этим вирусом и смертельных случаев от COVID-19 в пересчёте на 100 тысяч жителей было значительно ниже в регионах, где потреблялось больше растительной пищи, чем продуктов животного происхождения.

КЛЮЧЕВЫЕ СЛОВА: диета; короновирус SARS-CoV-2; пандемия COVID-19; патогенез; эпидемия; факторы риска

## Introduction

The current COVID-19 pandemic was announced by WHO on March 11, 2020 [1]. The disease was caused by the highly transmitted from person to person SARS-CoV-2 coronavirus. COVID-19 (Corona Virus Infectious Disease) was detected in China at the end of 2019 and a newly discovered coronavirus was identified moreover genome of SARS-CoV-2 rapidly sequenced [2-4]. This is a very dangerous infectious disease that affects a huge number of people on all continents and countries [5-6]. Epidemiologists and virologists have suggested that global infection with the highly pathogenic SARS-CoV-2 virus will continue for more than a year or two. The COVID-19 pandemic is a global health, medical, social and economic challenge now and as well as in the future. Many diverse factors increasing the onset and course of COVID-19 disease have been evaluated and analyzed [5,7-17]. This review analyzes the influence of dietary factors on the development of the SARS-CoV-2 epidemic process on five continents and in some of their regions in order to assess the effectiveness of factors that can reduce the consequences of a severe infectious disease.

## Points of view on the etiology and pathogenesis of the SARS-CoV-2 virus

Discovered at the end of 2019, the new virus was announced by the International Committee on Taxonomy of Viruses as SARS-CoV-2. The large and combined RNA virus belongs to the genus Betacoronavirus, the Coronaviridae family. Coronaviruses cause respiratory tract infections in birds and mammals. Betacoronaviruses are highly transmissible, enveloped, heavyweight and complex RNA viruses that cause several acute respiratory infections in humans [2-4, 18]. The SARS-CoV-2 beta-coronavirus is extremely contagious to humans, and pathogen virions spread among people through aerosol-generated particles and primarily enter type 2 pneumocytes attaching to the host angiotensin-converting enzyme (ACE2) [2-3,19-20]. Conventionally, the life cycle of pathogenic viruses transmitted by airborne droplets is determined by the main stages: infection, replication, release and transmission of virions. The stage of infection includes the following phases: presence of a sensitive object in the environment; invasion of the respiratory tract; transport to sensitive tissues and endocytosis into host cells. The replication stage consists of the following phases: synthesis of viral polypeptides and RNA; the formation of a protovirus; assembly of virion components. The third stage is: the exit of daughter virions from the cell, departure from the host and spread. The genome of coronaviruses encodes the structure of several proteases that are important for the successful invasion and productive replication of the pathogen [2-4].

COVID-19 is currently known as a very dangerous infectious disease that causes fatal pathogenic symptoms. Five main variants of the severity of COVID-19 disease have been identified: asymptomatic, subclinical, acute with convalescence, chronic and lethal [5,7-8]. The predominantly clinical manifestation of COVID-19 is pneumonia, which can lead to SARS and critical lung damage in a very short time. Moreover, the virus is toxic and destructive to other human organs. The SARS-CoV-2 virus can destroy tissue and cause multiple organ failure during infection [7-8,21-22], as well as cause a dangerous post-COVID syndrome called Long-COVID [5,7,23-24]. In the current conditions of a pandemic, it would be very useful to find natural factors that prevent the development of a serious illness.

## Consequences of the pandemic fifteen months later

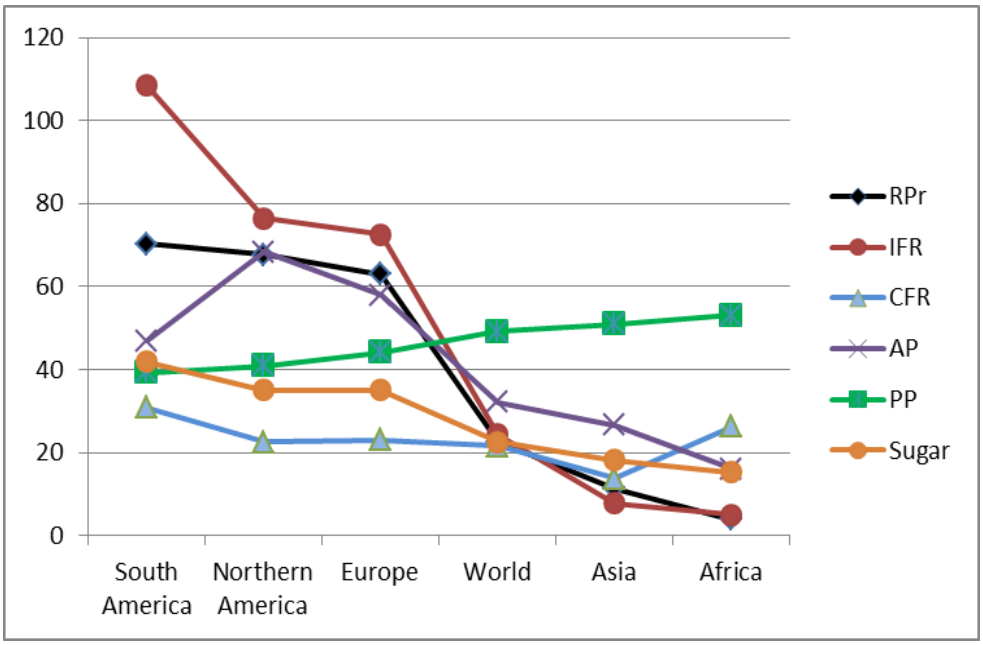
On Thursday, June 10, 2021, 15 months have passed since the WHO announced the COVID-19 pandemic [1], but no clear scientific prediction of the end date has yet been made. By this time, cases of infection have been confirmed in all countries and several thousand circulating variants of the SARS-CoV-2 virus have been identified [5-7]. New mutants with higher transmission rates are emerging in different regions, indicating that, there are no signs of

weakening of the global pandemic. Most likely, the number of cases of infection will continue to increase in the form of growing waves.
This review discusses the COVID-19 pandemic data collected over the study period, March 11, 2020 to June 10, 2021. During the 15 months of the study-period about 175,606 thousand cases of viral infection were confirmed globally, which is 2.25% of the world's population [5-6]. The largest number of infected patients on this date was observed in Europe and Asia, together on these continents 57% of those infected with the virus SARS-CoV-2 lived [6].
In North America (NA), the majority of those infected were in the United States (USA), South America in Brazil, Europe in France, Asia in India, and the African continent in South Africa [5-6]. In these five countries, almost 50% of the globally detected cases of the SARS-CoV-2 virus with the spread of special variants [5-7] were reported. However, the relative number of deaths in these countries from different continents varies considerably. They were more in line with the average level of their continent [6],
On this date, 3,789 thousand deaths were registered in the world, which was 2.16% of all infected patients. Until June 10, 2021, data on mortality from COVID-19 disease in the world grew in the form of four growing waves [6]. As the number of people infected increases, the number of deaths will rise on all continents. Reducing the number of incidences and deaths from COVID-19 is an urgent task in the fight against coronavirus. To do this, it is important to analyze the epidemiological data and determine the factors that can actually reduce the pathogenesis of the SARS-CoV-2 virus.
Infection or mortality rates vary greatly from region to region and from country to country. These data may differ by a factor of a hundred or a thousand, which is why some publications question the fact that statistical information on epidemiological processes from different countries was absolutely reliable [25]. Despite the opinion that the analysis of a large database has its drawbacks, which are especially evident with a heterogeneous sample [26], for greater reliability, the influence of socio-economic factors on the course and outcomes of the SARS-CoV-2 coronavirus was analyzed using a large number of representative statistics and a long study period [27-29].

**Risk factors for the epidemic process COVID-19**

The pathogenic coronavirus SARS-CoV-2 has paralyzed all human activities around the world for more than a year, making it impossible to resolve the global health and economic crisis. The number of confirmed infected cases around the world is growing every day and is rising in the next fifth wave [6]. Decisions about the course of each epidemic are based on an analysis of statistics on circulating infection in the population over the time period described. Epidemiologists, infectious disease specialists, clinicians and other experts analyze primarily the risks of an epidemic (pandemic) and their factors [5,8-17,27-29]. The following available sources differentiate or assess risk factors for severity or mortality from COVID-19 [5,7].
The elevated mortality rate among high incomed patients suffering from COVID-19 has been unexpectedly recognized [12,29]. A similar trend was found in statistical populations of continents [28].
Africa is characterized by a low standard of living: GDP is 32 times, consumption of high-calorie foods is 2.2 times, protein intake is 1.6 times lower than in NA [6,30-31], and the infection rate was 18 times, and the level of mortality rate was 22 times lower [6,15,28]. This difference for NA and Asia was less contrasting (Fig. 1), but also significant; accordingly, the infection fatality rate (IFR) and rate of prevalence (RPr) were several times lower in Asia, than in NA [28].
The influence of socio-economic factors on the pathogenesis of the virus was investigated and it was shown that the level of consumption of fats and total protein can be a reliable factor

influencing the pathogenesis of the SARS-CoV-2 virus [28]. In the non-white (black and South-Asian) groups in the USA or Great Britain population, the rates of incidence and mortality were higher than in the white group [11-12,16]. These studies support the idea that eating habits rather than ethnicity are the risk factors for COVID-19.




| Factor | RPr | IFR | CFR |
|---|---|---|---|
| IFR | 0,97 | | |
| CFR | 0,46 | 0,60 | |
| AP | **0,92** | **0,80** | 0,17 |
| PP | **-0,98** | **-0,98** | -0,49 |
| wP | 0,84 | 0,69 | 0,03 |
| Sugar | **0,99** | **0,99** | 0,52 |

**Fig. 1. Relation between outcomes of COVID-19 pandemic and diet factors on five continents**

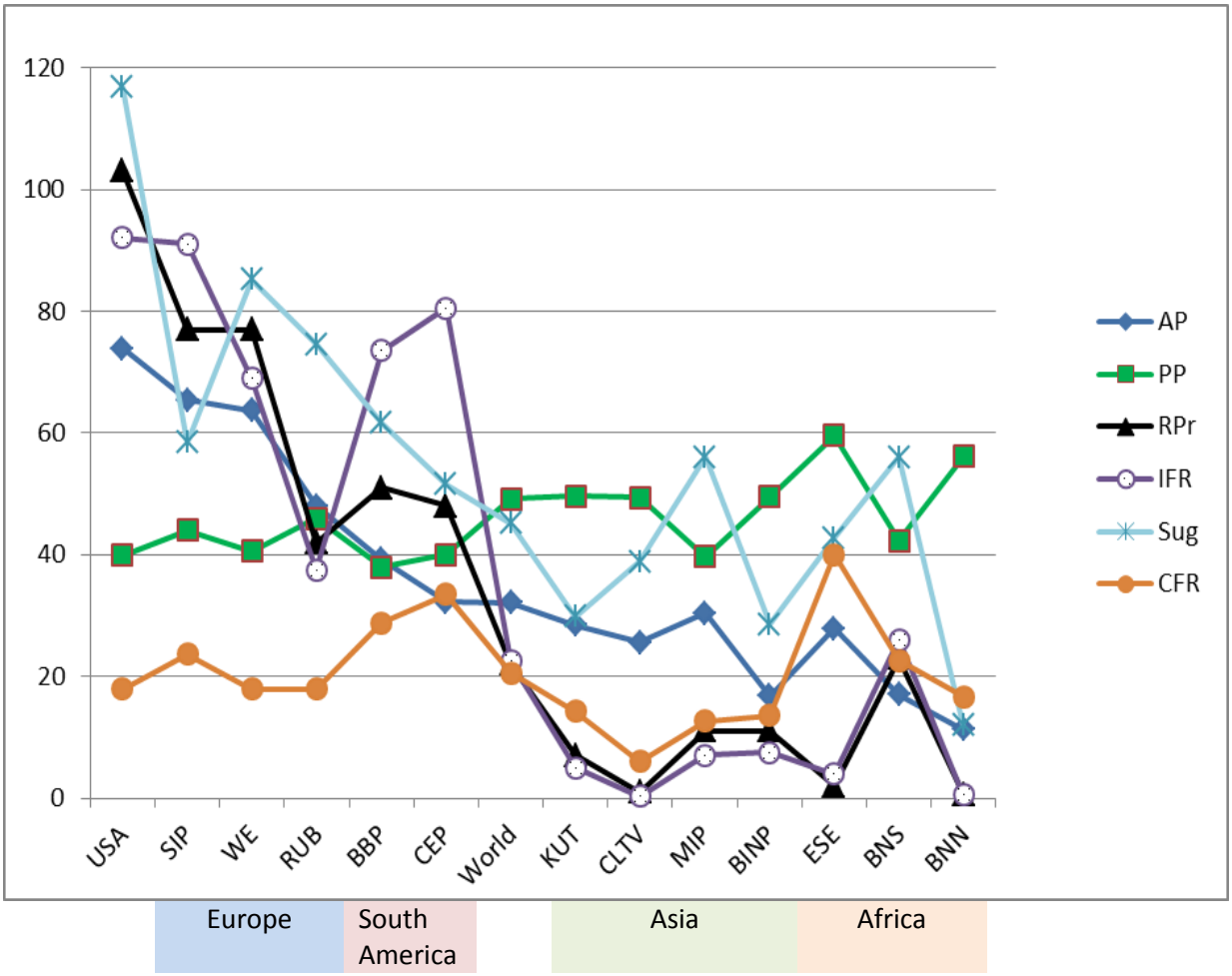
Correlation between rate of prevalence (RPr), infection fatality rate (IFR) or case fatality rate (CFR) of the SARS-CoV-2 infection and amount of consumed animal protein (AP), plant protein (PP), whole protein (wP) or sugar (Sugar).
AP, PP, wP in g/day/person [31], Sugar in Kg/year/capita [https://www.indiansugar.com/PDFS/World_per_Capita_Consumption_of_Sugar.pdf]. Accessed: 20.08.2021.
RPr = total amount infected/1000 population (10.06.2021) [6],
IFR= total amount deaths/50 000 population (10.06.2021),
CFR = Total COVID-19 deaths/ Total cases.
WHO recommendation: maximum 50 g sugar and its products per day per capita [https://www.ages.at/en/topics/nutrition/who-sugar-recommendations/]. Accessed: 20.08.2021
Below are correlation coefficients (r) between COVID-19 outcomes and different factors of diet.

**Relation between dietary habits and progress of SARS-CoV-2 infection**

Many publications and reviews have suggested that a person's diet plays an important role in the development of COVID-19 outcomes [32-40]. For a long time, nutritionists believe that an optimal diet helps in the fight against diseases, including infectious ones, since proper nutrition improves the immune system and strengthens the body's defenses [32, 38-41]. Nutritional deficiencies and low metabolic rates have been suggested to exacerbate the disease and increase mortality [32,34,36,42]. Therefore, patients with COVID-19 were recommended, an enriched diet with all essential nutrients, vitamins and minerals [5,36,38,42-43]. It was suggested, that a Mediterranean diet can reduce the risk of severe SARS-CoV-2 disease and COVID-19 mortality [44]. Several studies have shown that COVID-19 disease was worsening not only due to malnutrition, but also due to obesity [33-37]. To combat the infectious disease COVID-19, excessive consumption of fatty and protein foods was recommended [38]. Opposite assumptions were the following: a plant-based diet is beneficial for recovery from COVID-19 [45] and the severity of the development of the epidemic process of SARS-CoV-2 in humans directly depends on the amount of fat and protein consumed, as has been shown for populations of continents and different regions [28].

Proteins are vital macronutrients for the animal body. People get animal and plant proteins from food. On the continents of Asia and Africa, plant food (Fig. 1) predominates (66% and 76% of the total protein, respectively). Nations in Europe and America have consumed more fat and protein for many decades than in Asia or Africa (Fig. 1), and this is also much more than the WHO recommendation [41,46]. The diet of Europeans and North Americans is dominated by animal proteins (58 and 68 g/person/day), namely 57% of the total protein consumed. Inhabitants of Africa consume 4.2 times, and in Asia 2.6 times less animal protein than in NA. At the same time, the maximum difference in the amount of vegetable protein consumed by a person on different continents ranges from 25% to 30% (in NA 41, in Asia 51 and in Africa 53 g per day). People in some Asia countries consume less fat, and in Africa, much less protein than the WHO recommendation [5,41,46]. The inhabitants of these two continents consume significantly less animal protein than the world average. In Fig.1 is shown a direct association between the rate of prevalence (RPr) or IFR on five continents and the amount of animal protein consumed, with correlation coefficients $r = 0.92$ for incidence or $r = 0.8$ for mortality. These correlation coefficients for total protein were smaller: 0.84 or 0.69, respectively, for the same continents [28]. All indicators of SARS-CoV-2 for continents: RPr; IFR and case fatality rate (CFR) show a higher correlation for vegetable protein than for animal protein with $r = -0.98$; $r = -0.98$ and $r = -0.49$. Obviously, the correlation between the severity of COVID-19 and the amount of plant or animal proteins eaten is more pronounced (Fig. 1) than with total dietary protein [28]. A direct correlation between the level of manifestation of viral pathogenesis and the amount of plant proteins consumed on the continents was obtained for both RPr and IFR (Fig. 1).

A similar analysis was carried out for the selected groups of countries [28] on each continent. To do this, epidemiological data were analyzed for grouped countries from each continent, and the relationship was presented for most of these countries: lower consumption of fat and total protein correlates with less severe pathogenicity of the SARS-CoV-2 [15,28]. A side effect of COVID-19 is an increase in plasma cholesterol in patients [47]. A diet rich in fat amplifies the amount of circulating ACE [48], which explains the positive correlation between fat intake and the RPr or IFR of COVID-19 [28,49]. Here, the same groups of countries [28] were used to analyze risk factors for infection with SARS-Cov-2 (Fig. 2).




| Factor | RPr | IFR | CFR |
|---|---|---|---|
| IFR | 0,94 | | |
| CFR | 0,16 | 0,35 | |
| AP | 0,92 | 0,8 | 0,06 |
| PP | -0,66 | -0,7 | 0,07 |
| Sug | 0,86 | 0,72 | 0,07 |
| AP/PP | 0,95 | 0,85 | 0,06 |
| wP | 0,69 | 0,45 | 0,16 |

**Fig. 2. Relation between outcomes of the COVID-19 pandemic and diet factors in different country groups of five continents**

Correlation between rate of prevalence (RPr), infection fatality rate (IFR) or case fatality rate (CFR) of the SARS-CoV-2 infection and amount of consumed animal protein (AP), plant protein (PP), whole protein (wP) or sugar (Sug). AP, PP, wP in g/day/person, sugar in Kcal/day/capita/5 [31].
RPr = total amount infected/1000 population (10.06.2021) [6], IFR= total amount deaths/50 000 population (10.06.2021), CFR = Total COVID-19 deaths/ Total cases.
On abscissa axis are names of country groups taken from [28].
Below are correlation coefficients (r) between COVID-19 outcomes and different factors of diet.

The tendency of the dependence of the severity of COVID-19 on the amount of consumed animal proteins revealed for the continents (Fig. 1) also manifests itself (Fig. 2) for the previously selected groups of countries [28]. In Ethiopia and Nigeria, from ESE and BNN groups (Fig. 2), the population consumes 12 and 10 times less animal-based protein than in the USA and, accordingly, the frequency of infection with the virus was 44 and 129 times lower. In addition, inhabitants of these two African countries consume 7.5 and 5.6 times less sugar than residents of the USA (Fig. 2). In countries with low consumption of sugar and its derivatives, the incidence of SARS-CoV-2 virus infection was usually lower. The correlation coefficients of the dependence of RPr or IFR on the amount of sugar eaten were for selected groups 0.8 or 0.7, respectively (Fig. 2). To reduce the risk of glucose in COVID-19 disease it was suggested to use non physiological glucose analogues for therapy. A review by Paoli and coauthors suggested that elevated blood glucose suppresses the antiviral response, stimulates the expression of ACE2 receptors in animal tissues increasing the severity of COVID-19 [50]. The trend in the severity of COVID-19 across country groups matches the consumption of both animal-based protein and sugar with its derivatives (Fig. 2).
Although there may be exceptions in the correlation for some countries, in which, in the short period before the study day of the pandemic, the number of infected patients increased sharply due to the penetration of new variants of the SARS-CoV-2 virus with a very high infectivity. So has been happened in May and June of this year in Peru, Brazil and India [5-7]. At the end of April 2021, such a phenomenon was recorded in a group CPS [28] of Central European countries (Czech, Poland and Slovak Republics), whose residents consume less fat, sugar and animal proteins [6,46], but the date on infection and mortality rates (RPr and IFR) were significantly higher than in neighboring West-Europe [6,28]. In South Africa Republic also in the BBP and CEP groups from Southern America, in contrast to other countries, mortality jumped out of the trend of dependence on the amount of fat and protein consumed. In these countries, the escalation of the pathogenic process of the SARS-CoV-2 virus may be influenced by more contagious variants of the virus (Beta- and Gamma) [5,7]. The influence of dietary factors on the number and rate of transmission of virions, or on the basic reproduction number (Ro) should be principally minimal.

**Regional diets and pathogenic effects of the SARS-CoV-2 coronavirus**

The next two country groups, RUB and CLTV, were well outside the trend line in terms of the rates of infections (RPr) or deaths (IFR) (Fig. 2). In the countries of these two groups, people consume less protein and fat than Europeans [28,46], moreover the intervals between waves of infection were much longer than the world average [6]. Thus, in the RUB group, the numbers of RPr and IFR were 70% and 55% of the average data for the whole of Europe.
In the CLTV region, RPr and IFR values were extremely lower than the average for Asia (928 and 6 per million, respectively) [6], although the inhabitants of this region consume fats and animal proteins, almost equal to the average for the Asian continent [6,28,46]. The consumption of sugars in this group is not lower than [46] in other regions of Asia (Fig. 2). The diet in the CLTV region is plant-based with the high consumption of soy products (Table 1). The average world consumption of soybeans is 0.77 g/day/person [46]. Thus, in Vietnam with a high population density (314 people/sq. Km) [6,30] the incidence of coronavirus infection and mortality were among the lowest in the world (Fig. 1-2, Table 1). In this state residents consume the largest amount of soy protein per capita in the world (9.14 g per day) [46]. Also in Taiwan, with its very high population density (673 persons/ sq. Km [6,30]), infection and mortality rates were among the lowest in Asia [6,28]. The inhabitants of this island eat about 8 g of soy protein per day.

Despite the high heterogeneity of data in the group of Asian countries with high consumption of soybeans, the revealed relationship between the consumption of plant proteins and RPr or IFR remains higher than for fat, sugar or animal proteins (Table 1-2).
The Asian population, which consumes a lot of soy products, has the lowest infection rate not only in the world, but also in Asia (Fig.1-2), even with a high consumption of fatty or protein foods and a very high population density [6,30,46]. There is no relationship between RPr or IFR and the consumption of fat, sugar and soy in these countries (Table 2), which have been easy throughout the COVID-19 pandemic [6]. This reason for the very mild outcomes of the SARS-CoV-2 coronavirus needs to be investigated. Soybeans contain of wide variety of inhibitors of serine and other proteases, the activity of which was minimally reduced after prolonged boiling [51-53]. Are soybeans virucidal or food protease inhibitors able to disrupt the activity of viral enzymes important for the infectious process? The question of whether soy products help to block the development of the SARS-CoV-2 virus can be resolved after serious research.

Table 1. Diet factors and the outcomes of COVID-19 in South- and South-East Asia country group

| **Country / /Factor** | **RPr** | **IFR** | **Soy** | **AP** | **PP** | **Soy/AP** | **Fat** | **Sugar** |
|---|---|---|---|---|---|---|---|---|
| Vietnam | 100 | 0,6 | **9,14** | 36,8 | 53,2 | 24,84 | 79 | 108 |
| Taiwan | 512 | 15 | **8,70** | 42,5 | 43,3 | 20,47 | 127 | 275 |
| Japan | 6089 | 110 | **8,20** | 48,1 | 38,5 | 21,30 | 88 | 242 |
| Cambodia | 2165 | 18 | **4,42** | 19,2 | 46,2 | 23,02 | 34 | 216 |
| Pakistan | 4021 | 90 | **2,55** | 27,9 | 38,4 | 9,14 | 72 | 238 |
| Thailand | 1890 | 12 | **1,90** | 26,2 | 34,8 | 7,25 | 64 | 387 |
| Laos | 268 | 0,4 | **0,88** | 20,1 | 63,1 | 4,38 | 49 | 64 |
| World average | 22529 | 486 | **0,77** | 32,1 | 49,1 | 2,40 | 82,8 | 136 |

Note: Correlation between average prevalence (RPr), infection fatality rate (IFR) or case fatality rate (CFR) of the SARS-CoV-2 infection, and amount of consumed animal protein (AP), plant protein (PP), fat (Fat) or sugar (Sugar). Soy, AP, PP, Fat in g/day/person [31], Sugar in Kg/year/capita [https://www.indiansugar.com/PDFS/World_per_Capita_Consumption_of_Sugar.pdf]. Accessed: 20.08.2021. RPr = total amount infected/1mln population (10.06.2021) [6], IFR= total amount deaths/1mln patients (10.06.2021), Soy/AP in %%.

Table 2. Correlation coefficients (r) between COVID-19 outcomes and different food components

| **Factor** | **wP** | **AP** | **PP** | **Fat** | **Sugar** | **Soy** |
|---|---|---|---|---|---|---|
| **Soy** | 0,69 | 0,83 | -0,10 | 0,67 | -0,05 | |
| **RPr** | -0,18 | 0,35 | **-0,63** | 0,09 | 0,36 | 0,04 |
| **IFR** | -0,04 | 0,45 | **-0,56** | 0,18 | 0,24 | 0,12 |

Note: Correlation coefficients (r) were calculated from data in the Table 1.

The RUB group has the lowest population density in the selected Europe clusters [6,28,30]. In the countries of this group, the infection rate (RPr) was much lower and the relative mortality rate (IFR) slighter than the European average (Fig. 1-2). In this RUB region, residents consume less fat and protein than other Europeans [28,46]; however, the largest amount of potatoes in the world (6.17 g of protein per day per capita, or 13.4% of plant proteins eaten). In Belarus, on average, each inhabitant intakes 8 g of potato proteins per day, which is 18.6% of all consumed vegetable proteins [46]. This country had the lowest rates of both infection (RPr) and mortality (IFR) from COVID-19, not only in Europe, but also in the group [6]. Potatoes and soy are similar in producing of protease inhibitors and in affecting of digestion and uptake of nutrients in gastrointestinal tract. Potato tubers contain a wide range of different protease inhibitors with mass variation 5 - 160 KDa. Potatoes synthesize a large amount of protease inhibitors which are relatively thermostable and have low Ki [53-55]. Interested researchers should investigate whether potato products can directly suppress infection or reduce the severity of COVID-19 disease.

In traditional medicine, especially in Asian countries, numerous herbs or natural remedies are widely used to fight various infections including coronavirus [53,56-57]. The structure and mechanism of action of different synthetic inhibitors of viral proteases are known [15, 58], the role and anti-viral effect of other components has been analyzed [47,53,58-61]. In light of these studies, the effect of plant foods should be investigated. Unfortunately, the attending physicians have not yet paid serious attention to the effect of the amount of consumed macronutrients on the pathogenesis of COVID-19 and its consequences.

**Conclusions**

After 15 months of the COVID-19 pandemic the global community has learned some key lessons. A quantitative analysis was carried out, using large statistical samples, of influence of the staple food components on the effectiveness of infection with the SARS-CoV-2 virus and the severity of the COVID-19 disease. A direct correlation was found between the severity of the development of COVID-19 and the amount of dietary proteins, fats and sugars consumed. Analysis using big epidemic data showed that in case with the minimum rate of SARS-CoV-2 pathogenic outcomes, the level of ingested fats, sugars and proteins of animal origin was low or not significantly higher than the WHO recommended. Countries with high consumption of soy or potato products had lower morbidity and mortality rates from COVID-19 than neighbors. A high intake of plant-based proteins was correlated with a low severity of COVID-19. Perhaps not only soy or potatoes, but also other dietary vegetables, contain substances to help organism to be resist against pathogens including the SARS-CoV-2 virus. The nature of these effects of dietary factors on the host-pathogen interaction should be proved by methods of nutritional biochemistry and molecular biology of metabolism.

The established relationship between nutritional factors and the outcomes of SARS-CoV-2 infection requires detailed study. Most likely, overconsumption of essential nutrients is not critical to the stages of transmission or infection, but to the reproduction of the coronavirus. From the publications cited and this analysis of statistical data, it follows that the type of diet may be a decisive factor in the development of the pathogenesis of COVID-19. Consequently, a specific recommendation arises to combat the epidemic in Europe and America, namely: to reduce the consumption of saccharides, lipids and animal proteins during the COVID-19 pandemic. Models of national food-based dietary guidelines need to be developed.

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