Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Original Article

Usage of nutritional supplements to improve immunity during the COVID-19 pandemic: An online survey

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SUMMARY

Background and aims: Proper nutrition to optimise immune function is mandatory as at present there is no specific medicine to cure COVID-19. Our study aimed to investigate the use of nutritional supplements and their key immunity enhancing components among Sri Lankans.

Methods: This current study was an online survey conducted during the period from 27th May to 2nd June 2021 disseminated via various social media platforms. Details were collected on highlighting the frequency and composition of nutritional supplements consumed.

Results: In a total of 3707 responders, a proportion of 25.5% (944) of the participants took supplements regularly, and 32.6% (1210), 14.5% (538), 27.4% (1015) intake were occasionally, rarely and never respectively. Older participants (>40 years of age) had a significantly higher intake of supplements than the younger counterpart of 31–35 years age group (OR: 0.604; 95% CI, 0.451–0.809; $p < 0.001$). Almost half (46.0%) took vitamin C supplements and females tend to take more (OR: 1.325; 95% CI, 1.120–1.567; $p < 0.001$) of vitamin C when compared to males. Comparatively to the other groups regarding monthly income, the participants with the highest income category are more likely to take vitamin D (OR:1.899; 95% CI, 1.034–3.490; $p = 0.039$) and multivitamin (OR: 3.222; 95% CI, 1.737–5.977; $p < 0.001$). The most commonly used main ingredient in home-made remedy was coriander in Sri Lanka.

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Conclusion: The use of nutritional supplements and natural products to improve immunity during the pandemic were frequent among Sri Lankan adults. In general, older, female gender and high income was significantly associated with increased intake of the nutrient supplements.

Introduction

The coronavirus disease 2019 (COVID-19) pandemic advanced relentlessly worldwide since the first cluster of cases of infection [1]. As of 31st of May 2021, it has spread over 222 countries, and caused a total of 17 million and 3.5 million active cases and deaths respectively [2]. The novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has resulted in a substantial increase in hospitalisations for pneumonia with multi-organ disease worldwide [3]. Expression of the virus ranges from asymptomatic to life-threatening, presenting flu-like symptoms to severe lung injury in high-risk older individuals with multiple co-morbidities [4]. COVID-19 remains a global health challenge, having triggered an enormous number of human causalities and serious economic losses to countries [5]. Therefore, infection prevention, early viral detection and identification of treatment protocols provide the best approach in controlling the disease spread.

Multiple therapeutic strategies are used to treat patients with COVID-19, while no specific drugs are recommended to cure it [6]. The fundamental prevention measures such as mask-wearing, social distancing and handwashing are universally recommended [7]. In addition to the basic preventative measures, vaccination has been identified as a key strategy for preventing the infection globally [8]. A substantial population need to be vaccinated to achieve safe herd immunity to control transmission of the COVID-19 virus [9]. The demand for vaccines is expected to overcome the supply and disparities in vaccine doses across high and low-income countries can be seen [10]. In addition, it is well known that proper nutrition can support optimal immune function thus reducing the impact of infections [11].

The global burden of the COVID-19 pandemic infection is significant, requiring further safeguards. Achieving a balanced diet has become extremely challenging during this epidemic [12]. Protein-energy malnutrition and/or micronutrient deficiency are associated with an impaired immune system [13,14]. Micronutrient deficiencies are highly prevalent in the South Asian region and deficiencies of iron, zinc, vitamin D and vitamin B_{12} are well established [15]. A review evaluating nutrition-based interventions for respiratory viral infections, reported vitamins A and D as well as trace minerals like selenium and zinc to have immune-modulatory effects [16]. Furthermore, the same review showed vitamin C had no beneficial evidence against viral infections, and similarly vitamin E supplementation indicated no effect and may be detrimental [16]. During this epidemic, commonly recommended supplements by dieticians were fish oil, vitamin D, multivitamin, probiotics, and vitamin C [17].

Along with micronutrients, natural products with therapeutic properties such as ginger, turmeric, garlic, and others are utilised as home-based remedies which hold immune-modulating properties that may improve immunity against diseases [18]. According to a study conducted on the use of herbs and natural products in the Saudi population during the COVID-19 pandemic, 69.3% believed that these practices can improve their immunity [19]. Additionally, a survey in Bangladesh reported that 57.6% of the participants had used herbal foods/products, with tea (71%) being the most popular, followed by ginger (56.5%), black seed (32.8%), honey (30%), and clove (30%) [20].

Hence, dietary supplements defined as usable amounts of micronutrients have become a growing interest during the COVID-19 as they are widely used to potentially improve immune health [21]. Moreover, complementary and alternate medicine as Ayurveda and herbal supplements are frequently used as treatments globally [22]. Sri Lanka as a lower-middle-income country, experienced its most severe outbreak of the COVID-19 pandemic during the study period. Therefore, the main aim of this

online survey was to investigate the use of nutritional supplements and their key immunity-enhancing components among Sri Lankans during the COVID-19 pandemic.

Methods

Study design and sampling

The present study is a national-level online survey conducted using Google forms, a web survey platform during the period from 27th May to 2nd June 2021. Recruitment of participants was carried out using multiple strategies. The link to the online survey was circulated across various social media platforms, and the detailed methodology is published elsewhere [23]. No incentives were given to the participants and the active promotion of the questionnaire was completely voluntary. Informed consent was taken prior to the administration of the questionnaire. The web-based survey was performed accordingly to the ethical principles laid by the World Medical Association Declaration of Helsinki [24]. The nature of anonymity and the impossibility to trace any sensitive data required no ethical approval [25].

Questionnaire

The online questionnaire was constructed using Google Forms and was made available in all three official languages; English, Sinhala, and Tamil. The participants could select the preferred language, and the questionnaire was anticipated to take 5–10 minutes to complete. The questionnaire was divided into two sections, each including personal and lifestyle details, with a focus on the use of nutritional supplements to improve immunity.

The first section investigated the participants' personal related data. Respondents' details of birth year, gender, district, area of residence, ethnicity, educational status, current employment status, and family details including the monthly income were collected by both open-ended and multiple-choice questions.

The second part of the questionnaire collected details on the usage of “immune nutrients”. The frequency and composition of nutritional supplements consumed were recorded. The frequency of the supplement intake was inquired using four options: regularly, occasionally, rarely, or never. The respondents were asked to select the nutritional supplements they consumed during this period from a list of nine options: vitamin C, vitamin D, multivitamin, *kothamalli* (*Coriandrum sativum* infused in water), Ayurvedic products, herbal products, home-made remedies, syrups, and others. To obtain more details on home-based remedies, the most common ingredient used was asked via an open-ended question.

Statistical analysis

Data were extracted from Google forms as an MS Excel spreadsheet (Version 16.50, Microsoft Corporation). The data were revised, coded, and fed into the statistical software IBM SPSS version 23 (SPSS, Inc. Chicago, IL) for statistical analysis. Descriptive analysis based on the frequency and percentage distribution was performed for all demographic variables and the results were expressed as a percentage (%) and numbers (n). The chi-square test was used to determine differences between categorical variables of interest. Multinomial and binary logistic regression analyses were conducted to investigate the association between categorical variables (dependent) and continuous or categorical ones (independent). During regression analyses, certain demographic variables representing less than 1% of the sample were removed. In addition, monthly family income groups of < 10,000 LKR and 10,000–24,999 LKR were combined together as < 25,000 LKR category. Education level groups of no schooling, primary and secondary education also were combined into a new category as ‘secondary education or below’. The results of logistic regression analyses were reported as odds ratio (OR) and 95% confidence intervals (95%; CI). The p-value was considered significant at <0.05.

Results

After removing potential duplicates and incomplete responses, a total of 3707 respondents were recorded before removing <1% categorical groups for analysis. The socio-demographic characteristics

of the participants are presented in Table 1. The majority belonged to the 26–30 years age group (24.7%; 913), were females (59.6%; 2209), and had an education level of degree or above (69.1%; 2563). The survey conducted covered all 25 districts in the country with the highest reporting from Colombo (37.8%; 1408) and most of the responders were from rural areas 40.1% (1488). Representation of all ethnic groups was recorded and the majority were Sinhalese (81.9%, 3036). In terms of employment

Table 1
Sample characteristics

Variables	Total (n=3707)	
	n	%
Age		
16–25 years	825	22.3
26–30 years	913	24.7
31–35 years	758	20.5
36–40 years	498	13.5
>40 years	705	19.1
Gender		
Male	1468	39.6
Female	2209	59.6
Not specified	30	0.8
District		
Colombo	1403	37.8
Gampaha	502	13.5
Kandy	352	9.5
Kalutara	235	6.3
Kurunegala	183	4.9
Batticaloa	108	2.9
Others	924	24.9
Area of residence		
Municipal council area	1208	32.6
City council area	1011	27.3
Rural area	1488	40.1
Ethnicity		
Sinhala	3036	81.9
Sri Lankan Tamil	304	8.2
Indian Tamil	57	1.5
Sri Lankan Moors	259	7.0
Others	51	1.4
Education level		
No schooling	2	0.1
Primary education (up to grade 5)	0	0
Secondary education (up to O/L)	160	4.3
Tertiary education (up to A/L)	948	25.6
Degree or above	2563	69.1
Prefer not to say	34	0.9
Employment status		
Employed	2337	63.0
Self-employed	200	5.4
Unemployed	272	7.3
Engaged in home duties	114	3.1
Retired from employment	55	1.5
Full time student or pupil	618	16.7
Other	84	2.3
Prefer not to say	27	0.7
Monthly family income (in LKR)		
Less than 10,000	89	2.3
10,000–24,999	231	6.2
25,000–49,999	605	16.3
50,000–99,999	986	26.6
100,000–199,999	887	23.9
>200,000	909	24.5

status and monthly income, more than half of the participants were employed (63.0%; 2337), and over a quarter of participants had a monthly income of 50,000–99,000 LKR (26.6%; 986).

Table 2 presents the associations between demographic variables and the frequency of taking nutritional supplements. Participants who never take supplements were 27.4% (1015) whereas rarely, occasionally, and regularly reported 14.5% (538), 32.6% (1210) and 25.5% (944) respectively. Among all the demographic variables, age, gender, ethnicity, employment status and monthly family income of the respondents indicated strong significant associations with the four frequencies of supplementation intake from taking it regularly, occasionally, rarely, or never ($p < 0.05$). The regression analysis among regular supplement intake by demographic variables was reported in Supplementary Table 1. The odds of regular intake of supplements are lower in all ages compared to the oldest group. Moreover,

Table 2
Association between demographic variables and frequency of taking nutritional supplements

Variables	Regularly	Occasionally	Rarely	Never	*p*-value
	n (%)	n (%)	n (%)	n (%)	
Total	944 (25.5)	1210 (32.6)	538 (14.5)	1015 (27.4)	
Age					
16–25 years	176 (21.3)	301 (36.5)	137 (16.6)	211 (25.6)	<0.001
26–30 years	225 (24.6)	307 (33.6)	144 (15.8)	237 (26.0)	
31–35 years	182 (24.0)	234 (30.9)	105 (13.9)	237 (31.3)	
36–40 years	139 (27.9)	170 (34.1)	51 (10.2)	138 (27.7)	
>40 years	220 (31.2)	195 (27.7)	100 (14.2)	190 (27.0)	
Gender					
Male	334 (22.8)	436 (29.7)	213 (14.5)	485 (33.0)	<0.001
Female	600 (27.2)	767 (34.7)	318 (14.4)	524 (23.7)	
District					
Colombo	377 (26.9)	440 (31.4)	187 (13.3)	399 (28.4)	0.082
Gampaha	129 (25.7)	163 (32.5)	83 (16.5)	127 (25.3)	
Kandy	85 (24.1)	118 (33.5)	46 (13.1)	103 (29.3)	
Kalutara	55 (23.4)	84 (35.7)	39 (16.6)	57 (24.3)	
Kurunegala	42 (23.0)	64 (35.0)	20 (10.9)	57 (31.1)	
Batticaloa	16 (14.8)	35 (32.4)	27 (25.0)	30 (27.8)	
Others	240 (26.0)	306 (33.1)	136 (14.7)	242 (26.2)	
Area of residence					
Municipal council area	311 (25.7)	393 (32.5)	171 (14.2)	333 (27.6)	0.939
City council area	244 (24.1)	333 (32.9)	155 (15.3)	279 (27.6)	
Rural area	389 (26.1)	484 (32.5)	212 (14.2)	403 (27.1)	
Ethnicity					
Sinhala	827 (27.2)	1015 (33.4)	411 (13.5)	783 (25.8)	0.001
Sri Lankan Tamil	61 (20.1)	82 (27.0)	52 (17.1)	109 (35.9)	
Indian Tamil	8 (14.0)	23 (40.4)	9 (15.8)	17 (29.8)	
Sri Lankan Moors	36 (13.9)	73 (28.2)	60 (23.2)	90 (34.7)	
Others	12 (23.5)	17 (33.3)	6 (11.8)	16 (31.4)	
Education level					
Secondary education or below	25 (15.6)	68 (42.5)	23 (14.4)	44 (27.5)	0.056
Tertiary education	249 (26.3)	313 (33.0)	134 (14.1)	252 (26.6)	
Degree or above	663 (25.9)	815 (31.8)	378 (14.7)	707 (27.6)	
Employment status					
Employed	610 (26.1)	735 (31.5)	333 (14.2)	659 (28.2)	0.021
Self-employed	52 (26.0)	67 (33.5)	24 (12.0)	57 (28.5)	
Unemployed	72 (26.5)	88 (32.4)	32 (11.8)	80 (29.4)	
Engaged in home duties	30 (26.3)	35 (30.7)	23 (20.2)	26 (22.8)	
Retired from employment	20 (36.4)	15 (27.3)	8 (14.5)	12 (21.8)	
Full time student or pupil	133 (21.5)	224 (36.2)	111 (18.0)	150 (24.3)	
Other	18 (21.4)	36 (42.9)	6 (7.1)	24 (28.6)	
Monthly family income (in LKR)					
< 25,000	64 (20.0)	88 (27.5)	47 (14.7)	121 (37.8)	<0.001
25,000–49,999	144 (23.8)	221 (36.5)	94 (15.5)	146 (24.1)	
50,000–99,999	244 (24.7)	340 (34.5)	153 (15.5)	249 (25.3)	
100,000–199,999	233 (26.3)	288 (32.5)	129 (14.5)	237 (26.7)	
>200,000	259 (28.5)	273 (30.0)	115 (12.7)	262 (28.8)	

participants from 31-35 years age group reported significantly lower intake of supplements compared to older > 40 years age category (OR:0.604; 95% CI, 0.451–0.809; $p = 0.001$). In addition, males were less likely to have regular supplement intake (OR:0.589; 95% CI, 0.485–0.716; $p < 0.001$) compared to the female counterpart. However, a clear significant difference of regular supplement intake was seen among participants who earned more than > 200,000 LKR when compared with < 25,000 LKR (OR: 0.506; 95% CI, 0.336–0.761; $p < 0.001$).

Table 3a and 3b present the vitamins and multivitamin users during the COVID-19 pandemic respectively. The usage of vitamin C, vitamin D and multivitamin among the participants were 46.0% (1288), 8.6% (241), and 10.8% (302) respectively. As seen in Table 3a, vitamin D, and multivitamin intake had a significant association with age ($p < 0.05$). Overall females were more likely to take vitamin C supplementation (OR: 1.325; 95% CI, 1.120–1.567; $p < 0.001$) when compared to males. A strong significant correlation resulted between all districts and areas of residence with supplementation ($p < 0.001$). Odds ratio presented in Table 3b exhibited the district of Kandy had a less likelihood for intake of vitamin C (OR: 0.541; 95% CI, 0.0393–0.743); $p < 0.001$) and vitamin D (OR: 0.376; 95% CI, 0.201–0.700; $p = 0.002$) compared to Colombo district. Furthermore, the odds of a lower intake in the rural area were seen across all supplements especially with vitamin D (OR: 0.552; 95% CI, 0.394–0.774; $p = 0.001$) and multivitamin (OR: 0.570; 95% CI, 0.420–0.774); $p < 0.001$). Regarding the ethnicity, there was no association shown except for Sri Lankan Tamils indicating the lowest intake of vitamin C supplementation (OR: 0.558; 95% CI, 0.405–0.7688; $p < 0.001$) when compared to the Sinhala ethnicity group. Moreover, at all education levels supplements vitamin C, D and multivitamin demonstrated significant correlations (Table 3a). Analysis results of participants of tertiary education presented in Table 3b, were found more likely to take vitamin C (OR: 1.585; 95% CI, 1.054–2.384; $p = 0.027$) supplements when compared to those lower education levels. Employment status had a strong association with vitamin D and multivitamin intake (Table 3a). Monthly family income played a significant relationship with supplement intake, with participants earning >200,000 LKR more likely to take vitamin D (OR: 1.899; 95% CI, 1.034–3.490; $p = 0.039$) and multivitamin supplementation (OR: 3.222; 95% CI, 1.737–5.977; $p < 0.001$) when compared to the least earning category.

The usage of non-vitamin supplements across the participants to enhance the immune system is shown inSupplementary Table 2a and 2b. A majority of the participants (59.5%) consumed *kothamalli*, while other supplements used were Ayurvedic products (26.0%; 729), herbal products (10.9%; 306) homemade remedies (16.4%; 459), and syrups (1.3%; 36). Age, area of residence, education level, and employment status showed no associations with the intake of non-vitamin supplements. In regards to gender, females tend to use *kothamalli* more (OR: 1.324; 95% CI, 1.096–1.599; $p = 0.004$) than males. Intake of *kothamalli* and homemade remedies demonstrated a significant association between districts ($p < 0.001$) (Supplementary Table 2a). In Supplementary Table 2b, the participants from the district of Kandy showed a significantly higher intake of *kothamalli* (OR: 1.773; 95% CI, 0.182–2.659; $p = 0.006$) in contrast to participants from the Colombo district. Additionally, the likelihood of making homemade remedies was significantly higher in Kurunegala (OR: 2.481; 95% CI, 1.626–3.786; $p < 0.001$) and Batticaloa (OR: 1.857; 95% CI, 1.101–3.132; p = 0.020). The ethnic categories had a significant association with the consumption of *kothamalli* and Ayurvedic products ($p <0.001$; $p = 0.006$). In comparison, all other ethnicities significantly had a lower intake of both *kothamalli* and Ayurvedic products than Sinhala. Nonetheless, both Sri Lankan Tamils (OR: 2.268; 95% CI, 1.629–3.158; $p < 0.001$) and Indian Tamils (OR: 2.243; 95% CI, 1.174–4.285; $p = 0.041$) and as well as Sri Lankan Moors (OR:1.886; 95% CI, 1.333–2.670; $p < 0.001$) were most likely to make their own remedies at home compared to Sinhalese (Supplementary Table 2b). Monthly income had a significant association with *kothamalli* ($p < 0.001$) and ayurvedic products ($p = 0.002$) intake, of which Ayurvedic products was more likely to be consumed by participants earning 100,000–199,999 LKR (OR: 1.794; 95% CI, 1.208–2.665; $p = 0.004$) and 50,000–99,000 LKR (OR: 1.623; 95% CI, 1.109–2.376; $p = 0.013$) than the other income groups.

The most commonly used main ingredients in homemade remedies are displayed in Figure 1. Majority of the participants used coriander (57%; 629) and ginger (20%; 217) as main ingredients. Other commonly used ingredients were lime (4%; 49), garlic (4%; 48), lemon (3%; 37), turmeric (2%; 26) and pepper (2%; 20). The remaining 8% (87) belonged to the other group which mostly consisted of mixtures of herbs and other natural products.

Table 3a
Usage of vitamins and multivitamin among the supplement users during the COVID-19 pandemic

Variables	Vitamin C		Vitamin D		Multivitamin	
	n (%)	*p*-value	n (%)	*p*-value	n (%)	*p*-value
Total	1288 (46.0)		241 (8.6)		302 (10.8)	
Age						
16–25 years	257 (43.3)	0.277	27 (4.6)	<0.001	37 (6.2)	<0.001
26–30 years	333 (47.6)		58 (8.3)		72 (10.3)	
31–35 years	272 (44.7)		46 (7.6)		69 (11.3)	
36–40 years	198 (49.6)		39 (9.8)		55 (13.8)	
>40 years	224 (45.3)		70 (14.1)		69 (13.9)	
Gender						
Male	432 (40.6)	0.001	86 (8.1)	0.488	97 (9.1)	0.026
Female	843 (49.1)		152 (8.8)		203 (11.8)	
District						
Colombo	476 (47.8)	0.001	126 (12.7)	0.001	144 (14.5)	0.001
Gampaha	204 (48.3)		45 (10.7)		54 (12.8)	
Kandy	114 (35.5)		12 (3.7)		22 (6.9)	
Kalutara	102 (52.3)		18 (9.2)		15 (7.7)	
Kurunegala	66 (41.0)		8 (5.0)		11 (6.8)	
Batticaloa	6 (60.0)		1 (10.0)		0 (0.0)	
Others	320 (46.0)		31 (4.5)		56 (8.0)	
Area of residence						
Municipal council area	368 (49.4)	0.013	91 (12.2)	0.001	107 (14.4)	0.001
City council area	349 (47.7)		76 (10.4)		105 (14.3)	
Rural area	571 (43.1)		74 (5.6)		90 (6.8)	
Ethnicity						
Sinhala	1213 (46.3)	0.445	230 (8.8)	0.673	284 (10.8)	0.668
Sri Lankan Tamil	21 (43.8)		4 (8.3)		7 (14.6)	
Indian Tamil	6 (27.3)		1 (4.5)		1 (4.5)	
Sri Lankan Moors	37 (42.5)		4 (4.6)		7 (8.0)	
Others	11 (45.8)		2 (8.3)		3 (12.5)	
Education level						
Secondary education or below	48 (35.0)	0.018	5 (3.6)	0.014	9 (6.6)	0.001
Tertiary education	383 (48.1)		58 (7.3)		55 (6.9)	
Degree or above	848 (46.0)		178 (9.7)		237 (12.9)	
Employment status						
Employed	837 (47.2)	0.486	167 (9.4)	0.001	199 (11.2)	0.006
Self-employed	61 (40.9)		9 (6.0)		21 (14.1)	
Unemployed	97 (44.5)		19 (8.7)		21 (9.6)	
Engaged in home duties	47 (50.0)		10 (10.6)		18 (19.1)	
Retired from employment	17 (45.9)		8 (21.6)		3 (8.1)	
Full time student or pupil	194 (43.6)		17 (3.8)		29 (6.5)	
Other	24 (39.3)		7 (11.5)		7 (11.5)	
Monthly family income (in LKR)						
< 25,000	82 (36.4)	0.005	11 (4.9)	0.001	7 (3.1)	0.001
25,000–49,999	218 (42.9)		30 (5.9)		25 (4.9)	
50,000–99,999	384 (49.7)		48 (6.2)		66 (8.5)	
100,000–199,999	302 (45.8)		63 (9.5)		99 (15.0)	
>200,000	302 (47.6)		89 (14.0)		105 (16.5)	

Discussion

Sri Lanka was experiencing the highest number of COVID-19-infected patients and fatalities throughout the study period. Due to the limited vaccine coverage in Sri Lanka, alternative immunity-enhancing products have taken the attention of the general public. This online survey conducted explored various immunity-enhancing products during COVID-19, from nutritional supplements to many other natural products including herbs in Sri Lanka. Only a quarter of our survey respondents did not take any nutritional supplements to strengthen the immunity. Despite the fact that our study sample consisted mostly of young and educated people, we received a large number of responses from diverse ethnic groups and throughout all districts of the island, making our survey population a fair

Table 3b
Odds (OR) of vitamins and multivitamins usage among the supplement users by socio-demographic variables

Variables	Vitamin C		Vitamin D		Multivitamin	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Age						
16–25 years*	1		1		1	
26–30 years	0.981 (0.718–1.342)	0.907	0.994 (0.607–1.628)	0.982	1.123 (0.712–1.771)	0.619
31–35 years	0.899 (0.642–1.258)	0.533	0.802 (0.470–1.367)	0.417	1.282 (0.790–2.083)	0.315
36–40 years	1.031 (0.717–1.482)	0.870	1.046 (0.608–1.800)	0.872	1.232 (0.741–2.048)	0.421
>40 years	0.828 (0.587–1.168)	0.282	1.590 (0.962–2.630)	0.071	1.369 (0.843–2.224)	0.204
Gender						
Male*	1		1		1	
Female	1.325 (1.120–1.567)	0.001	1.300 (1.009–1.677)	0.043	1.280 (1.015–1.615)	0.037
District						
Colombo*	1		1		1	
Gampaha	0.950 (0.730–1.236)	0.701	0.813 (0.561–1.176)	0.271	0.946 (0.676–1.324)	0.747
Kandy	0.541 (0.393–0.743)	<0.001	0.376 (0.201–0.700)	0.002	0.725 (0.448–1.174)	0.191
Kalutara	0.976 (0.691–1.379)	0.891	0.861 (0.525–1.414)	0.555	0.562 (0.330–0.958)	0.034
Kurunegala	0.841 (0.564–1.252)	0.393	0.500 (0.242–1.035)	0.062	0.787 (0.429–1.446)	0.441
Batticaloa	0.976 (0.585–1.628)	0.927	0.707 (0.297–1.681)	0.433	0.672 (0.302–1.494)	0.330
Others	0.773 (0.618–0.969)	0.025	0.403 (0.275–0.590)	<0.001	0.672 (0.490–0.992)	0.014
Area of residence						
Municipal council area*	1		1		1	
City council area	0.956 (0.776–1.179)	0.677	0.761 (0.572–1.012)	0.060	0.936 (0.723–1.212)	0.618
Rural area	0.803 (0.647–0.997)	0.047	0.552 (0.394–0.774)	0.001	0.570 (0.420–0.774)	<0.001
Ethnicity						
Sinhala*	1		1		1	
Sri Lankan Tamil	0.558 (0.405–0.768)	<0.001	0.963 (0.580–1.600)	0.884	0.880 (0.556–1.393)	0.585
Indian Tamil	0.567 (0.303–1.061)	0.076	0.706 (0.263–1.893)	0.488	1.364 (0.636–2.925)	0.425
Sri Lankan Moors	0.759 (0.547–1.054)	0.099	0.682 (0.394–1.181)	0.172	1.007 (0.639–1.586)	0.976
Others	1.393 (0.649–2.992)	0.395	1.325 (0.563–3.120)	0.520	2.098 (0.982–4.480)	0.056
Education level						
Secondary education or below*	1		1		1	
Tertiary education	1.585 (1.054–2.384)	0.027	0.769 (0.388–1.525)	0.452	0.810 (0.420–1.565)	0.531
Degree or above	1.142 (0.758–1.720)	0.525	0.716 (0.363–1.413)	0.336	1.167 (0.610–2.232)	0.642

(*continued on next page*)

Table 3b (*continued*)

Variables	Vitamin C		Vitamin D		Multivitamin	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Employment status						
Employed*	1		1		1	
Self-employed	0.730 (0.514–1.038)	0.080	1.126 (0.683–1.859)	0.641	1.746 (1.127–2.706)	0.013
Unemployed	0.899 (0.649–1.247)	0.524	1.163 (0.704–1.921)	0.554	1.312 (0.814–2.113)	0.265
Engaged in home duties	0.676 (0.433–1.057)	0.086	0.823 (0.419–1.616)	0.571	1.509 (0.864–2.637)	0.148
Retired from employment	0.637 (0.338–1.203)	0.164	1.943 (0.957–3.943)	0.066	1.105 90.484–2.522)	0.812
Full time student or pupil	0.852 (0.611–1.188)	0.345	0.755 (0.429–1.328)	0.329	1.519 (0.935–2.468)	0.092
Other	1.097 (0.642–1.874)	0.735	1.693 (0.846–3.387)	0.137	1.749 (0.879–3.481)	0.111
Monthly family income (in LKR)						
<25,000*	1		1		1	
25,000–49,999	0.966 (0.688–1.355)	0.840	0.844 (0.442–1.612)	0.608	1.173 (0.610–2.256)	0.632
50,000–99,999	1.309 (0.943–1.816)	0.107	0.895 (0.486–1.646)	0.721	1.729 90.940–3.181)	0.078
100,000–199,999	1.008 (0.716–1.421)	0.962	1.341 (0.731–2.458)	0.343	2.787 (1.513–5.133)	0.001
>200,000	1.241 90.869–1.772)	0.234	1.899 (1.034–3.490)	0.039	3.222 (1.737–5.977)	<0.001

* Reference variable.

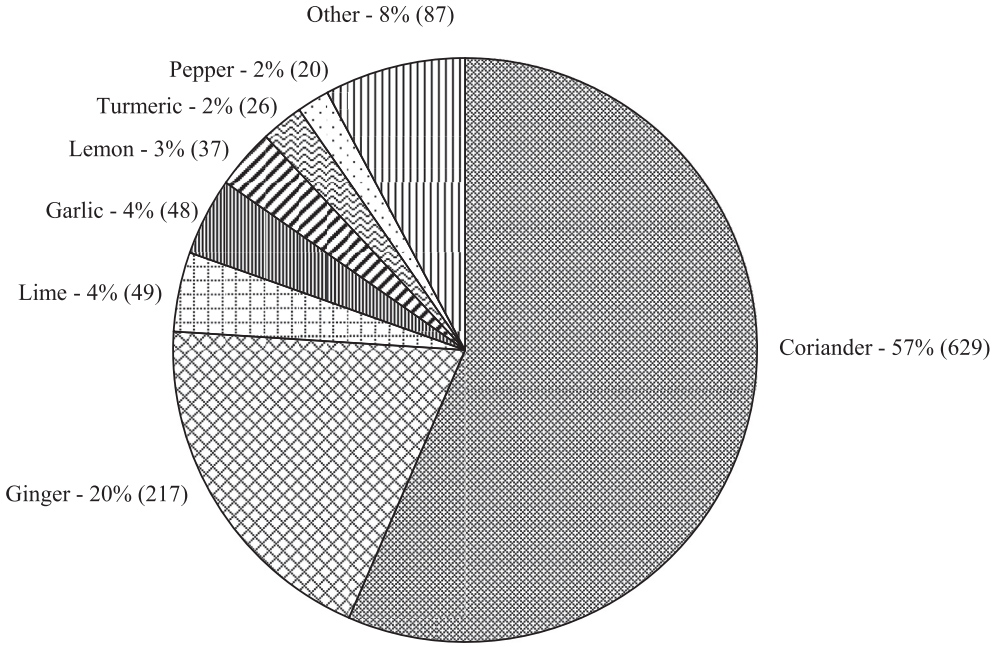

Figure 1. Common main ingredients used in home-made remedies.

reflection of Sri Lanka. The survey showcased frequencies of supplement intake to have significant differences across the various ethnicities, this is due to the difference in beliefs and practices belonging to the specific ethnic group. A similar study conducted in Benha city, Egypt during COVID-19 reported the use of vitamin C (27%), vitamin D (17.7%), immune-boosting drinks (39.3%), honey (32.2%), and garlic (37.2%) amidst the participants [26]. In Italy, most believed that strengthening immune defences through nutrition elements enhances the function of the immune system to reduce the risk of COVID-19 infection [27].

In this study, various demographic factors were associated with the frequency of nutritional supplement intake. Regular supplement intake was seen greater among the older (>40 years) participants in contrast to the younger counterpart. A similar pattern was observed in Bangladesh, where elderly individuals were more likely to take preventive supplements (OR: 2.93; 95% CI, 1.37–6.30; $p = 0.004$) [20]. Older age and/or existing co-morbidities are an increased risk factor for severe COVID-19 infection compared to the younger age group which may also cause elders to take extra measures to be more careful [28]. Higher intake of supplementation was also mostly seen across females than males. Our gender analysis results reflect similar patterns as of the online study among Polish adults [25]. A study which was conducted among Google users across multiple countries to investigate their interests in nutritional supplements during the COVID-19 pandemic period revealed that, the difference of interest was either because of traditional medicine knowledge or regional beliefs in the specific country [29]. Consistently, the difference between the ethnic groups indicates they do not share the same knowledge and attitudes on supplements use [30]. The lower-earning category of participants was significantly less likely to use supplements considering the supplements tend to be more expensive [31]. These results are similar to investigations done in other countries that have indicated supplement intake is greater among the high-income populations [32,33]. Since a greater proportion of our participants were educated, there was no difference in supplement intake found. Whereas other related studies during COVID-19 discovered such preventive behaviours were higher among educated participants [20,25].

In this study, a larger proportion (46.0%; 1288) used vitamin C supplements, which have been studied to stimulate various defense mechanisms including antimicrobial and immunomodulatory properties [34]. Nonetheless, a review on therapeutic vitamin C supplementation had no consistent

effect on the severity and the duration of the common cold [35]. A study in the USA with COVID-19 patients, were administered high doses of ascorbic acid and had no significant decrease of symptoms in comparison to standard care ($p = 0.25$) [36]. Contrarily, vitamin D and multivitamin supplementation intakes were higher among participants who were older, employed, and from affluent categories. Vitamin D and multivitamin supplementation are recommended as these can be effective, especially among individuals who are either deficient and in self-isolation or have bad dietary practices [16]. Furthermore, another study exploring dietary supplements effect on COVID-19 recorded lower risk of infection in participants taking multivitamins by 13% (OR = 0.87; $p < 0.001$.) and vitamin D by 9% (OR = 0.91; $p < 0.001$) [37]. As vitamin D deficiency has been associated with COVID-19 mortality rate in the Asian region, vitamin D supplementation could have a vital role in the prevention or treatment of the disease [38,39]. Accordingly, vitamin D supplementation was administered among elderly patients in France with COVID-19 and were less likely to exhibit severity (OR = 0.46; 95% CI, 0.01–0.81; $p = 0.033$) [40]. In comparison to these micronutrient supplements, other immunity enhancing products reported association with various factors; residing location and ethnicity which may have influenced by cultural practices and beliefs [41]. Besides, the use of such herbs and products was high probably due to the immediate availability in most households in Sri Lanka. Positive previous experiences with herbal therapy, as well as family traditions and practices, were among the most regularly mentioned reasons for the preferred use of herbal medicine in a focus group study in Germany [42].

Herbs and spices have been extensively studied around the world due to their greater demand for its natural food antioxidant and antimicrobial activity [43]. The majority (59.5%) of participants in our study took *kothamalli* to enhance their immunity. Coriander, has a long history as a traditional medicine, although a review investigating its bioactive constituents reported no effectiveness when treated for respiratory ailments such as asthma or bronchiolitis [44]. In Bangladesh, 57.6% proportion recorded the use of herbal foods to lower the risk of COVID-19 [20]. Additionally, a Saudi population study revealed approximately 44.8% of the participants used herbs and natural products daily as a protective measure with a significant increase of intake after COVID-19 [19]. Similarly, use of herbal products among patients were prevalent in the case of the previous infectious MERS outbreak in South Korea reporting 76.1% of patients used one or more type of herbal products [45]. Home-made remedies were made including various herbs and natural products, the commonly used ingredients were coriander, ginger, lime, garlic and lemon. In Morocco as well, garlic, and ginger were among the frequently consumed natural products during the pandemic [46]. Previous studies have reported that such ingredients could help in boosting an individual's immunity and may strengthen the immune system in general but just not related to the COVID-19 infection [18,47,48].

The current study has some limitations. Self-reported weight and height values in this study population were inaccurate therefore BMI values were not utilised, a previous study conducted in Sri Lankan adults showed only one-fourth can report weight and height accurately [49]. The questions asked regarding immunity enhancing supplements, only included the type and frequency of supplements but the doses are key. For instance, vitamin D supplementation at a dose of 5000IU per day is found to be more effective [16]. Moreover, not all multivitamins contain all the required vitamins and minerals as some may contain limited ingredients. A few of our questions were vague and overlapping. In the case of distinction between herbs and Ayurvedic products, as *kothamalli*/coriander is usually suggested under Ayurveda. In spite of the limitations, the main aim of this study was to report the types of supplements and the frequency of intake among the general public. Most countries studied similar patterns of usage frequency across various nutritional supplements [19,20,25,26]. These data are critical for making informed policy decisions at the national level. There are false claims and some products may have adverse effects on human health. Furthermore, some supplements may be overly expensive. The primary objectives of COVID-19 preventive measures are to follow public health guidelines, a balanced diet and daily physical movement. If deficiencies are present, nutritional supplementation may deem to be beneficial.

Conclusion

This study explored the proportion of Sri Lankans using nutrition supplements such as micronutrients, herbs, and other natural products to enhance their immunity during the COVID-19

pandemic. Nearly three quarter of the population take micronutrient supplements to enhance immunity. Age, gender, residing district, and income groups are strongly associated with supplement intake. A significant proportion of the participants takes non-evidence based vitamins such as vitamin C and herbs such as coriander in Sri Lanka.

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Conflicts of interest

The authors declare that they have no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contributions

RJ, TVF, PS conceived and designed the online survey questionnaire; disseminated the questionnaire; PS analysed and interpreted the data, TVF and RJ drafted the manuscript. PS revised the manuscript. All authors read and approved the final manuscript.

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Appendix A. Supplementary data

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References

[1] Kaswa R, Govender I. Novel coronavirus pandemic: a clinical overview. South African Family Practice 2020;62:1–5. https://doi.org/10.4102/safp.v62i1.5123.
[2] COVID Live Update: 171,084,997 Cases and 3,557,998 Deaths from the Coronavirus – Worldometer 2021. https://www.worldometers.info/coronavirus/ [Accessed 31 May 2021].
[3] Wiersinga WJ, Rhodes A, Cheng AC, Peacock SJ, Prescott HC. Pathophysiology, transmission, diagnosis, and treatment of coronavirus disease 2019 (COVID-19): a review. JAMA 2020;324:782–93. https://doi.org/10.1001/jama.2020.12839.
[4] Pascarella G, Strumia A, Piliego C, Bruno F, del Buono R, Costa F, et al. COVID-19 diagnosis and management: a comprehensive review. J Intern Med 2020;288:192–206. https://doi.org/10.1111/joim.13091.
[5] Ahn DG, Shin HJ, Kim MH, Lee S, Kim HS, Myoung J, et al. Current status of epidemiology, diagnosis, therapeutics, and vaccines for novel coronavirus disease 2019 (COVID-19). J Microbiol Biotechnol 2020;30:313–24. https://doi.org/10.4014/jmb.2003.03011.
[6] Jean SS, Lee PI, Hsueh PR. Treatment options for COVID-19: the reality and challenges. J Microbiol Immunol Infect 2020;53:436–43. https://doi.org/10.1016/j.jmii.2020.03.034.
[7] Ma QX, Shan H, Zhang HL, Li GM, Yang RM, Chen JM. Potential utilities of mask-wearing and instant hand hygiene for fighting SARS-CoV-2. J Med Virol 2020;92:1567–71. https://doi.org/10.1002/jmv.25805.
[8] Chung JY, Thone MN, Kwon YJ. COVID-19 vaccines: the status and perspectives in delivery points of view. Adv Drug Deliv Rev 2021;170:1–25. https://doi.org/10.1016/j.addr.2020.12.011.
[9] Chung YH, Beiss V, Fiering SN, Steinmetz NF. COVID-19 vaccine frontrunners and their nanotechnology design. ACS Nano 2020;14:12522–37. https://doi.org/10.1021/acsnano.0c07197.
[10] Unequal Vaccine distribution self-defeating, world health organization chief tells economic and social council's special ministerial meeting - World | ReliefWeb. 2021. https://reliefweb.int/report/world/unequal-vaccine-distribution-self-defeating-world-health-organization-chief-tells [Accessed 31 May 2021].
[11] Pecora F, Persico F, Argentiero A, Neglia C, Esposito S. The role of micronutrients in support of the immune response against viral infections. Nutrients 2020;12:1–45. https://doi.org/10.3390/nu12103198.
[12] Jayawardena R, Misra A. Balanced diet is a major casualty in COVID-19. Diabetes and Metabolic Syndrome. Clin Res Rev 2020;14:1085–6. https://doi.org/10.1016/j.dsx.2020.07.001.

[13] Iddir M, Brito A, Dingeo G, del Campo SSF, Samouda H, la Frano MR, et al. Strengthening the immune system and reducing inflammation and oxidative stress through diet and nutrition: considerations during the COVID-19 crisis. Nutrients 2020; 12. https://doi.org/10.3390/nu12061562.
[14] Chandra RK. Protein-energy malnutrition and immunological responses. J Nutr 1992;122:597–600. https://doi.org/10.1093/jn/122.suppl_3.597. Oxford Academic.
[15] Gopalan HS, Misra A, Jayawardena R. Nutrition and diabetes in South Asia. Eur J Clin Nutr 2018;72:1267–73. https://doi.org/10.1038/s41430-018-0219-6.
[16] Jayawardena R, Sooriyaarachchi P, Chourdakis M, Jeewandara C, Ranasinghe P. Enhancing immunity in viral infections, with special emphasis on COVID-19: a review. Diab Metab Synd Clin Res Rev 2020;14:367–82. https://doi.org/10.1016/j.dsx.2020.04.015.
[17] Kamarli Altun H, Karacil Ermumcu MS, Seremet Kurklu N. Evaluation of dietary supplement, functional food and herbal medicine use by dietitians during the COVID-19 pandemic. Pub Health Nutr 2021;24:861–9. https://doi.org/10.1017/S1368980020005297.
[18] Sultan MT, Buttxs MS, Qayyum MMN, Suleria HAR. Immunity: plants as effective mediators. Crit Rev Food Sci Nutr 2014; 54:1298–308. https://doi.org/10.1080/10408398.2011.633249.
[19] Abdullah Alotiby A, Naif Al-Harbi L. Prevalence of using herbs and natural products as a protective measure during the COVID-19 pandemic among the Saudi population: an online cross-sectional survey. Saudi Pharma J 2021. https://doi.org/10.1016/j.jsps.2021.04.001.
[20] Ahmed I, Hasan M, Akter R, Sarkar BK, Rahman M, Sarker MS, et al. Behavioral preventive measures and the use of medicines and herbal products among the public in response to COVID-19 in Bangladesh: a cross-sectional study. PLoS One 2020;15. https://doi.org/10.1371/journal.pone.0243706.
[21] Rautiainen S, Manson JE, Lichtenstein AH, Sesso HD. Dietary supplements and disease prevention-a global overview. Nat Rev Endocrinol 2016;12:407–20. https://doi.org/10.1038/nrendo.2016.54.
[22] Medagama AB, Bandara R, Abeysekera RA, Imbulpitiya B, Pushpakumari T. Use of complementary and alternative medicines (CAMs) among type 2 diabetes patients in Sri Lanka: a cross sectional survey. BMC Complement Alternat Med 2014; 14:1–5. https://doi.org/10.1186/1472-6882-14-374.
[23] Sooriyaarachchi Piumika, Francis Tormalli V, King Neil, Jayawardena R. Increased physical inactivity and weight gain during the COVID-19 pandemic in Sri Lanka: an online cross-sectional survey. Diab Metabol Synd Clin Res Rev 2021 [Under revi].
[24] World Medical Association declaration of Helsinki. Ethical principles for medical research involving human subjects. JAMA 2013;310:2191. https://doi.org/10.1001/jama.2013.281053. 4.
[25] Hamulka J, Jeruszka-Bielak M, Górnicka M, Drywień ME, Zielinska-Pukos MA. Dietary supplements during COVID-19 outbreak. Results of Google trends analysis supported by PLifeCOVID-19 online studies. Nutrients 2021;13:1–17. https://doi.org/10.3390/nu13010054.
[26] Khabour OF, Hassanein SFM. Use of vitamin/zinc supplements, medicinal plants, and immune boosting drinks during COVID-19 pandemic: a pilot study from Benha city, Egypt. Heliyon 2021;7:e06538. https://doi.org/10.1016/j.heliyon.2021.e06538.
[27] Savarese M, Castellini G, Morelli L, Graffigna G. COVID-19 disease and nutritional choices: How will the pandemic reconfigure our food psychology and habits? A case study of the Italian population. Nutr Metab Cardiovas Dis 2021;31: 399–402. https://doi.org/10.1016/j.numecd.2020.10.013.
[28] Gao Y dong, Ding M, Dong X, Zhang J jin, Kursat Azkur A, Azkur D, et al. Risk factors for severe and critically ill COVID-19 patients: a review. Allergy Eur J Allergy Clin Immunol 2021;76:428–55. https://doi.org/10.1111/all.14657.
[29] Günalan E, Cebioğlu İK, Ö Çonak. The popularity of the biologically-based therapies during coronavirus pandemic among the Google users in the USA, UK, Germany, Italy and France. Complement Therap Med 2021;58:102682. https://doi.org/10.1016/j.ctim.2021.102682.
[30] Adegboye ARA, Ojo O, Begum G. The use of dietary supplements among African and Caribbean women living in the UK: a cross-sectional study. Nutrients 2020;12. https://doi.org/10.3390/nu12030847.
[31] Cowan AE, Jun S, Gahche JJ, Tooze JA, Dwyer JT, Eicher-Miller HA, et al. Dietary supplement use differs by socioeconomic and health-related characteristics among U.S. adults, NHANES 2011–2014. Nutrients 2018;10. https://doi.org/10.3390/nu10081114.
[32] Tsang SN, Herbold NH, Pycz L. Dietary supplement use among active multi-ethnic adults. J Am Diet Assoc 2007;107:A34. https://doi.org/10.1016/j.jada.2007.05.359.
[33] Fennell D. Determinants of supplement usage. Prevent Med 2004;39:932–9. https://doi.org/10.1016/j.ypmed.2004.03.031.
[34] Leibovitz B, Siegel B v. Ascorbic acid, neutrophil function, and the immune response. Int J Vitamin Nutr Res 1978;48: 159–64.
[35] Hemilä H, Chalker E. Vitamin C for preventing and treating the common cold. Cochrane Database Syst Rev 2013;2013. https://doi.org/10.1002/14651858.CD000980.pub4.
[36] Thomas S, Patel D, Bittel B, Wolski K, Wang Q, Kumar A, et al. Effect of high-dose zinc and ascorbic acid supplementation vs usual care on symptom length and reduction among ambulatory patients with SARS-CoV-2 infection: the COVID A to Z randomized clinical trial. JAMA Network Open 2021;4:e210369. https://doi.org/10.1001/jamanetworkopen.2021.0369. e210369.
[37] Louca P, Murray B, Klaser K, Graham MS, Mazidi M, Leeming ER, et al. Modest effects of dietary supplements during the COVID-19 pandemic: Insights from 445 850 users of the COVID-19 symptom study app. BMJ Nutr Prevent Health 2021. https://doi.org/10.1136/bmjnph-2021-000250. bmjnph-2021-000250.
[38] Jayawardena R, Jeyakumar DT, Francis Tv, Misra A. Impact of the vitamin D deficiency on COVID-19 infection and morality in Asian countries. Diabetes and Metabolic Syndrome: Clinical Research and Reviews 2021;15:757–64. https://doi.org/10.1016/j.dsx.2021.03.006.
[39] Sooriyaarachchi P, Jeyakumar DT, King N, Jayawardena R. Impact of vitamin D deficiency on COVID-19. Clin Nutr ESPEN 2021. https://doi.org/10.1016/j.clnesp.2021.05.011.

[40] Annweiler G, Corvaisier M, Gautier J, Dubée V, Legrand E, Sacco G, et al. Vitamin d supplementation associated to better survival in hospitalized frail elderly COVID-19 patients: The Geria-COVID quasi-experimental study. Nutrients 2020;12: 1–12. https://doi.org/10.3390/nu12113377.
[41] Bishop FL, Yardley L, Lewith GT. A systematic review of beliefs involved in the use of complementary and alternative medicine. J Health Psychol 2007;12:851–67. https://doi.org/10.1177/1359105307082447.
[42] Welz AN, Emberger-Klein A, Menrad K. Why people use herbal medicine: insights from a focus-group study in Germany. BMC Complement Alternat Med 2018;18:1–9. https://doi.org/10.1186/s12906-018-2160-6.
[43] Embuscado ME. Spices and herbs: natural sources of antioxidants – a mini review. J Funct Foods 2015;18:811–9. https://doi.org/10.1016/j.jff.2015.03.005.
[44] Laribi B, Kouki K, M'Hamdi M, Bettaieb T. Coriander (*Coriandrum sativum* L.) and its bioactive constituents. Fitoterapia 2015;103:9–26. https://doi.org/10.1016/j.fitote.2015.03.012.
[45] Hwang JH, Cho HJ, Im H bin, Jung YS, Choi SJ, Han D. Complementary and alternative medicine use among outpatients during the 2015 MERS outbreak in South Korea: a cross-sectional study. BMC Complement Med Therapies 2020;20:147. https://doi.org/10.1186/s12906-020-02945-0.
[46] Alami A el, Fattah A, Chait A. Medicinal plants used for the prevention purposes during the COVID-19 pandemic in Morocco. J Anal Sci Appl Biotechnol 2020;2:4–11. https://doi.org/10.48402/IMIST.PRSM/jasab-v2i1.21056.
[47] Elmowalid GA, Abd El-Hamid MI, Abd El-Wahab AM, Atta M, Abd El-Naser G, Attia AM. Garlic and ginger extracts modulated broiler chicks innate immune responses and enhanced multidrug resistant *Escherichia coli* O78 clearance. Comp Immunol Microbiol Infect Diseases 2019;66. https://doi.org/10.1016/j.cimid.2019.101334.
[48] Wang K, Conlon M, Ren W, Chen BB, Bączek T. Natural products as targeted modulators of the immune system. Clin Develop Immunol 2021;2018. https://doi.org/10.1155/2018/7862782.
[49] Jayawardena R, Byrne NM, Soares MJ, Katulanda P, Hills AP. Body weight perception and weight loss practices among Sri Lankan adults. Obesity Res Clin Pract 2014;8. https://doi.org/10.1016/J.ORCP.2013.05.003.