IRON AND VITAMINS

SOURCE GUIDE

Prepared by
Meshari A. Al-Roudan

KUWAIT INSTITUTE FOR SCIENTIFIC RESEARCH

NATIONAL SCIENTIFIC & TECHNICAL INFORMATION CENTER

TECHNICAL SERVICE DEPARTMENT

September 2022

Table of Content

Introduction

Vitamins and minerals are nutrients your body needs in small amounts to work properly and stay healthy. Most people get all the nutrients they need from a varied and balanced diet, although some people may need to take extra supplements (NHS, 2022).

The National Scientific & Technical Information Center (NSTIC) has produced this source guide for Food and Nutrition Department (F&N).

This source guide highlights some of the latest journal articles for the period 2020–2022 using Science Direct, Scopus, and Elsevier.

Title: Occupational Cement Dust Exposure and Inflammatory Nemesis: Bangladesh Relevance.

Authors: Ahmad, R., Akhter, Q. S., & Haque, M.

Journal: *Journal of Inflammation Research.* **Date**: 2021

DOI: https://doi.org/10.2147/JIR.S312960

Prolonged, repeated exposure to cement dust, depending on duration and sensitivity of cement dust-exposed workers, may cause deteriorating effects on the skin, eye, respiratory and hematological system. Toxic cement dust causes inflammatory damage to different body organs. White blood cells (WBCs) are considered cellular markers of ongoing tissue inflammation.

Title: Tree Age and Harvesting Season Affected Physico-Chemical and Bioactive Compounds of Elite Type of Gunda Gundo Orange (Citrus Spp) in the Northern Ethiopia.

Authors: Aregay, N., Belew, D., Zenebe, A., Haile, M., Gebresamuel, G., & Girma, A.

Journal: *International Journal of Fruit Science.* **Date**: 2021

DOI: https://doi.org/10.1080/15538362.2020.1852150

Marketability and nutritional content are critical factors that need to be considered when a quality of orange fruit is assessed. Among the many factors affecting orange fruit quality, tree age and harvesting season are crucial once; however, the factors remained unmapped. Thus, this study was aimed to explore quality of orange fruit due to differences in tree age and harvesting season. Three trees age groups (young = 10 to 16, moderate = 20 to 27 and old = greater than 30 years) grown at Gunda Gundo monastery and its surroundings, northern Ethiopia and are harvested in October and December. The physico-chemical and antioxidant contents were characterized during two consecutive years (2017–2018). R software (R version 3.6.2) was used for the analysis. The highest single fruit weight of 218.71 g, peel thickness (3.6 mm) and pH (3.73) were obtained from young tree age in 2017. Total soluble solid of 13.4° Brix was recorded from moderate tree age in 2017, while 13.3° Brix was recorded from older trees of October harvest in 2018. High rag mass of 41.78% in October of 2017 and 38.04% in December of 2018 harvest were obtained from fruits of young trees. High vitamin C (53.95 mg 100 ml−1) and total sugar (11.1%) from the young trees; the highest juice mass (52.04%) from moderate trees age; and the highest phenolic content (9.15 mgGAEg−1), iron-reducing power (54.2 mgAAEg−1), total antioxidant (26.55 mgBHTg−1) and lower DPPH EC50 value (1.5 mg ml−1) from fruits of older tree were obtained. This experimental study results show that old trees age had high antioxidant activity.

Title: Nutrient Analysis of School Lunches and Anthropometric Measures in a Private and Public School in Chennai, India.

Authors: Bergman, E., Krishnan, D., Englund, T. F., Gururajan, R., & Gerrish, H.

Journal: *Health Information Science and Systems.* **Date**: 2020

DOI: https://doi.org/10.1007/s13755-020-0101-5

School lunch programs have been implemented as a method to facilitate better learning environments for children. These programs bring together the importance of adequate nutrition for academic performance, growth and development. This study served to assess the impact of the School Lunch Program in India and observe measures related to nutrition adequacy and stunting in school aged children in Chennai, India. Dietary and anthropometric data were collected among students of ages 7 to 10 in a privately funded ($n = 64$) and a publicly funded school ($n = 28$). Bioelectrical Impedance Analysis was assessed for private school students. BMI for Age Z-scores for the private school (0.05 ± 1.36) (mean ± standard deviation) and public school (-0.91 ± 2.01) were significantly different ($p = 0.008$). Additionally, 32% of public school students exhibited mild stunting, classified as Z-scores less than -1. Total calories consumed during the private school lunch was 269 ± 112 and 463 ± 234 for the publically funded school. Analysis of nutritional parameters of meals suggest that adequacy was otherwise fair during this singular analysis but does not provide evidence to correlate body composition and long term implications of malnutrition with this study population. Additional longitudinal analysis is required to better assess these implications.

Title: Effects of Dietary Supplementation with the Antimicrobial Peptide WK3 on Growth Performance and Intestinal Health in Diarrheic Weanling Piglets.

Authors: Cao, C., Li, J., Ma, Q., Zhang, L., & Shan, A.

Journal: *Journal of Applied Animal Research.* **Date**: 2021

DOI: https://doi.org/10.1080/09712119.2021.1916507

This study aimed to determine the effects of the antimicrobial peptide WK3, as an alternative to antibiotics, on diarrheic piglets. Before treatment, all pigs were orally challenged with 108 CFU/ml enterotoxigenic Escherichia coli (ETEC) K88 for 3 days. Piglets were randomly divided into 3 treatments of eight piglets each, namely, the control treatment, antibiotic treatment and antimicrobial peptide treatment. The experimental results show that the addition of the antibacterial peptide WK3 to the diet can significantly reduce the chance of diarrhea. Compared with the CON group, average daily gain (ADG) and average daily feed intake (ADFI) of the WK3 group ($P < 0.05$) increased. Compared with that with the control treatment and antibiotic treatment, the level of GSH-Px in the jejunum significantly increased ($P < 0.05$) with WK3 supplementation. The numbers of bacteria, Lactobacillus spp. ($P < 0.01$) and Bifidobacteria spp. ($P < 0.01$), were higher in the WK3 group, but Enterobacterium spp. in digesta of the cecum were depleted ($P < 0.01$). The WK3 group decreased the expression levels of the inflammatory factors IL-1α ($P < 0.05$) and TLR-4 ($P < 0.01$) in the jejunal mucosa contrast to the control treatment.

Title: Role of Nutrients Regulation in the Immune System in Preventing Covid-19 Infection: A Brief Review.

Authors: Chauhan, A.

Journal: *Journal of Applied and Natural Science.* **Date**: 2021

DOI: https://doi.org/10.31018/JANS.V13I2.2572

This review aimed to focus on using foods to boost immunity against COVID-19 in all age groups. In human, coronavirus causes the common cold, severe acute respiratory syndrome (SARS), and a major threat to public health. The novel coronavirus was declared a pandemic by the World Health Organization due to its rapid infectivity. COVID-19 infection is most probably reported in people with low immunity response. The nutrients, which show beneficial effects on the immune system, are called immune nutrients and diet is called immune diet. A healthy diet can reduce the risk of infection of COVID-19 and can prevent disease. Nutritional food intake is also necessary for people with chronic illness, obese persons, diabetes, cardiovascular disease, cognitive dysfunction like anxiety and depression. All nutrients are essential for maintaining immunity and providing appropriate amounts of protein, fat, carbohydrate, vitamins, and minerals for the surveillance mode of keeping us from getting sick. The use of plenty of water, minerals such as micronutrients, zinc, copper, selenium, iron, magnesium, food rich in vitamins, and a good lifestyle can promote health and overwhelm this coronavirus infection.

Title: Comparison of Chemical, Mineral and Vitamin Composition of Primal and Retail Cuts Of 1+ Grade Hanwoo Steer Beef.

Authors: Cho, S., Choi, Y., Seol, K., Kang, S. M., Va, H. B., Kim, Y., Kim, J., Seong, P., Moon, S., & Seo, H.

Journal: *Journal of the Korean Society of Food Science and Nutrition.* **Date**: 2021

DOI: https://doi.org/10.3746/JKFN.2021.50.4.369

The objective of this study was to compare the nutritional composition (e.g., calories, vitamins, and minerals) of 10 primal cuts and 37 retail cuts of 1+ grade Hanwoo beef. Out of 10 primal cuts, loin, striploin, brisket, and rib cuts had the highest energy (288.17~336.41 kcal) and fat (23.61~29.36%) content. Significantly lower and higher protein content was found in the ribs (16.05%) and top round (22.14%), respectively, compared to the other cuts in the 10 primal cuts studied. An analysis of the retail cuts in each primal cut showed that the chuck flap had significantly higher energy, fat, and cholesterol than the loin cut. While studying the top round and bottom round cuts, no significant variations were observed among the retail cuts in terms of the energy and cholesterol content but higher protein content was found in the rump (21.82%) and the outside round (21.50%) and higher fat content in the outside round head (13.81%) and the tri-tip

(13.74%). In the rib cuts, the neck chain was higher in protein (21.13%) and lower in fat and cholesterol than the other retail cuts. Among the primal cuts studied, the top round (top inside round, 2.64 mg), bottom round (rump, 2.87; outside round head, 2.75; knuckle, 2.86 mg) and ribs (hanging tender, 3.38; outside skirt, 3.25 mg) had significantly higher iron content than the other retail cuts in the same primal cuts. A study of the vitamin content showed that the highest thiamin, riboflavin, and pantothenic acid levels were found in the bottom round (0.062 mg), tenderloin (0.231 mg), and shank (2.89 mg) among 10 primal cuts, respectively. These results would be helpful in selecting retail cuts of Hanwoo beef based on nutritional information.

Title: Community-Based Nutrition-Sensitive Approach to Address Short-Term Hunger and Undernutrition Among Primary School Children in Rural Areas in a Developing Country Setting: Lessons from North and North-Eastern Uganda.

Authors: Elolu, S., & Ongeng, D.

Journal: *BMC Nutrition.* **Date**: 2020

DOI: https://doi.org/10.1186/s40795-020-00399-8

Undernutrition in childhood is an important factor that greatly impedes the achievement of full human potential at adulthood. Despite increased enrolment of pupils in primary schools in developing countries, short-term hunger and undernutrition continue to impact negatively on school attendance, retention and education outcomes in economically disadvantaged rural areas. This study examined the feasibility of a community-based participatory action research approach building capacity of rural women food vendors to use local food resources to produce nutritionally enhanced food products for primary school feeding in rural localities in a developing country setting.

Title: Affordable Processing of Edible Orthopterans Provides a Highly Nutritive Source of Food Ingredients.

Authors: Fombong, F. T., Kinyuru, J., Ng'ang'a, J., Ayieko, M., Tanga, C. M., Broeck, J. V., & Van Der Borght, M.

Journal: *Foods.* **Date:** 2021

DOI: https://doi.org/10.3390/foods10010144

Edible orthopterans (grasshoppers, crickets, and locusts) are major delicacies, especially across sub-Saharan Africa. Their promotion as food ingredients is increasingly gaining momentum. This study evaluates the nutritional profiles of three widely consumed orthopterans: Gryllus bimaculatus, Locusta migratoria, and Schistocerca gregaria after blanching and oven-drying. All three species had high protein (65.3, 54.2, and 61.4% on a dry matter (DM) basis for G. bimaculatus, L. migratoria, and S. gregaria, respectively) and fat contents. Oleic (22.9–40.8%) and

palmitic (26.1–43.0%) were the two most abundant fatty acids. All essential amino acids (in mg/100 g protein) were present, with glutamic acid (120–131), alanine (90.2–123), and leucine (82.3–84.6) being the most abundant. The minerals (in mg/100 g dry matter) potassium (796–1309) and phosphorus (697–968) were moderately high, and iron (4.60–7.31), zinc (12.7–24.9), manganese (0.40–7.15), and copper (1.20–4.86) were also observed in the samples. Vitamin B12 contents were high (0.22–1.35 µg/100 g dry matter). Our findings demonstrate that the excellent nutritional profile of the three processed insects could serve as promising alternative ingredients for improving food and nutritional security.

Title: Nutrition in Fasting and Non-Fasting Women during the Great Orthodox Lent.

Authors: Galchenko, A. V., Sherstneva, A. A., Lapik, I. A, Kulesh, V. I., Sukhno, E O, Zarov, A Y., & Revyakina, V. A.

Journal: *Ekologiya Cheloveka (Human Ecology).* **Date:** 2021

DOI: https://doi.org/10.33396/1728-0869-2021-3-15-24

To compare nutrition of fasting and non-fasting women in Moscow. Methods: Daily intake of proteins, fats, carbohydrates and their fractions, water- and fat-soluble vitamins, macro-, micro- and ultra trace elements as well as the total caloric content of diet was estimated in 33 fasting and 32 non-fasting women during the Lent. Nutrition was assessed by frequency analysis using Nutrilogic software. Results: Fasting women had significantly higher intake of carbohydrates (412 g vs. 174 g) and fiber (42 g vs. 17 g), but lower intake of cholesterol (74 mg vs. 401 mg) and saturated fats (18 g vs. 30 g). Fasting women were less likely to consume insufficient amounts of vitamins B1 (12 % vs. 91 %), B3 (52 % vs. 91 %), B5 (52 % vs. 91 %), B6 (48 % vs. 88 %), B9 (42 % vs. 94 %) and E (24 % vs. 72 %), potassium (6 % vs. 41 %), magnesium (21 % vs. 91 %), iron (18 % vs. 81 %) and copper (3 % vs. 41 %). $P < 0.001$ for all comparisons. All women consumed insufficient amount of vitamin D with food. Conclusion: Diet of fasting women had more favourable macro- and micronutrient composition and was richer in vitamins except vitamin D. This dietary pattern may be associated with health benefits in fasting women.

Title: The Promise and Challenges of Vegetable Home Gardening for Improving Nutrition and Household Welfare: New Evidence from Kasese District, Uganda.

Authors: Gerny, R., Marsh, R., & Mwebembezi, J.

Journal: *African Journal of Food, Agriculture, Nutrition and Development*. **Date:** 2021

DOI: https://doi.org/10.18697/ajfand.96.20125

Nearly eighty percent of Kasese District residents in Western Uganda pursue subsistence farming on the slopes of the Rwenzori Mountains where soil erosion and poverty contribute to declining agricultural yields, food insecurity, and high rates of stunting and wasting in children. In 2017, the

Rwenzori Center for Research and Advocacy (RCRA) began a pilot home garden program aimed at sustainably improving nutrition for vulnerable households in Kasese. In 2019, the research team investigated whether a home garden intervention for nutritional benefit is an effective entry point to achieve broad household welfare. Data were collected from fifty randomly selected households in four sites with varied degrees of exposure to the garden intervention. Methods included a questionnaire, innovative card sorting game (CSG), 24-hour recall nutrition survey, indepth interviews, and case stories of diverse Kasese women. Findings show that households experience diverse garden benefits and challenges depending upon baseline conditions, such as access to land, water, and money, as well as the quality and consistency of the technical and material support received. The frequency of vegetable consumption per day showed the most consistently positive results across households, while a 24-hour nutrition survey displayed increased consumption of leafy green vegetables high in iron and vitamin A among families with gardens, leading to 'stronger children' (CSG scenario) and improved family health. Further, over seventy percent of families generated income from their gardens, though varying widely in capacity to sell year-round. The garden income earned by women gardeners is spent almost entirely on child welfare. On average, more than ninety percent of garden households save ten percent of their income, primarily through Village Savings Groups. Therefore, regarding our research question, there is evidence to affirm that a home garden intervention for nutritional benefit can be an effective entry point to achieve broad household welfare. This conclusion is supported by numerous previous studies on garden initiatives for improved nutrition around the world.

Title: Vitamin-Mineral Isotonic Drinks with Spirulina in Sports Nutrition.

Authors: Gubanenko, G. A., Kudriavtsev, M. D., Rechkina, E. A., Naimushina, L. V., & Mayurnikova, L. A.

Journal: *Human Sport Medicine.* **Date:** 2020

DOI: https://doi.org/10.14529/HSM200315

The paper is aimed at developing isotonic vitamin and mineral drinks with spirulina, fruits and Siberian berries. Materials and Methods. Spirulina microalgae (Royal Forest, TU 03.21.49-009-29903295-2017) was purchased at the Healthy Food Products specialized store. The physicochemical parameters of spirulina powder were determined in accordance with GOST 31412-2010. The mineral composition of spirulina was studied by atomic emission spectroscopy (AES) using the Thermo Scientific iCaP-6500 DUO spectrometer and the iTEVA software package. The determination of vitamin content was carried out in accordance with GOST and pharmacopoeial standards. Directions for creating isotonic vitamin and mineral drinks with spirulina, fruits and berries were determined based on organoleptic criteria. Results. The mineral composition of spirulina (Royal Forest) was determined, and the content of macro- and microelements in spirulina was correlated with physiological norms for satisfying daily demand of an adult. It is shown that microalgae are a source of iron and copper as the content of these minerals in 100 g of the product reaches 27.9 and 66.3 % of recommended daily intake,

respectively. When studying the content of vitamins, it was found that thiamine and riboflavin showed the best indicators of ensuring daily demand of vitamins – 18.5 and 26.3 %, respectively. Based on the assessment of organoleptic properties, the recipes for isotonic vitamin and mineral drinks made of spirulina, fruits and berries are presented. Conclusion. It is shown that isotonic vitamin and mineral fruit and berry drinks with spirulina contain a vitamin-mineral complex and are characterized by increased nutritional and biological value. Such drinks can be recommended for extreme conditions and sports nutrition, including faster and better recovery after heavy physical exertion.

Title: Effects of Using Processed Barley and Supplemented Multi-Enzymes in Laying Hen Rations on Egg Production, Egg Quality, and Egg Fatty Acids.

Authors: Gürbüz, Y., & Özyürür, O.

Journal: *Turkish Journal of Veterinary and Animal Sciences.* **Date:** 2021

DOI: https://doi.org/10.3906/vet-2006-124

In this study, we have observed different technological processes, which are commonly used in poultry production. Rations contained different amounts of barley and multi-enzyme, egg weight, egg mass, egg yield, feed intake, egg weight. The rations of the control groups were as follows: 0% barley (based of corn) (K), 15% untreated barley (A1), 15% pellet barley (A2), 15% flaked barley (A3), 30% untreated barley (A4), 30% pelleted barley (A5), 30% flaked barley (A6), 30% untreated barley + enzyme (0. 025%) (A7). In the research, 64 brown laying hens ATAK-S for 36 weeks were divided into 8 different treatments for egg hens. Thirty-week-old laying hens were divided into 8 groups of 8 animals each with a similar live weight. Each treatment consisted of 8 animals in individual cages. Animals were completely randomly determined, grown in individual cages, and kept under a 16:8 h light: dark lighting period. Feed and water were given as ad-libitum. The highest egg weight was obtained from chickens fed with A2 group (62.98 g), and those chickens fed with A1 group (56.45 g) showed lowest egg weight ($p \leq 0.01$) In terms of total egg mass, the statistical differences between the experimental groups were very important, but A2 had the highest value and A4 group had the highest value. ($p \leq 0.01$). When considering the average feed consumption, feed consumption of A2 fed chickens was higher than the other groups ($p \leq 0.001$). Feed consumption of chickens fed A4 and A7 groups were significantly less than that of A1 group and K group feed consuming groups ($p \leq 0.001$). There was no significant difference in mean egg yield between treatments. When egg weight average was examined, it was found that egg weight was higher than A4 group's weight ratios when A7 group's added weighted ratio was considered ($p \leq 0.01$). When we examined the omega- 6 (n- 6) and omega-3 (n- 3) fatty acids in the trial, linolelaidic acid, one of the omega 6 fatty acids, was found to differ between treatments ($p \leq 0.05$). The lowest value for linolelaidic acid ranged from 0.022 in A3 group, while the highest value was 0.046 in A2 group.

Title: Assessment of The Effects of Liquid and Granular Fertilizers on Maize Yield in Rwanda.

Authors: Hatungimana, J. C., Srinivasan, R. T., & Vetukuri, R. R.

Journal: *African Journal of Food, Agriculture, Nutrition and Development.*

Date: 2021

DOI: https://doi.org/10.18697/ajfand.98.19670

Maize (Zea mays L.) is the most widely grown cereal in the world, accounting for 1,116.34 MT of production in 2019/2020. In Africa, this crop represented approximately 56% of the total cultivated area from 1990 to 2005. About 50% of the African population depends on maize as a staple food and source of carbohydrates, protein, iron, vitamin B, and minerals. Lately, maize has become a cash crop which contributes to the improvement of farmers' livelihoods. For example, the Strategic Plan for Agricultural Transformation (SPAT) III outlined that fertilizer availability in Rwanda should increase to 55,000 MT per year, while fertilizer use should increase from 30 kg/ha in 2013 to 45 kg/ha for the 2017/18 cropping season. Only inorganic fertilizers are currently being used in maize production in Rwanda. This research was conducted to assess the effects of liquid (CBX: Complete Biological Extract) and granular fertilizers on maize crop yields in Rwanda. The study was conducted in the fields of the Rwanda Agriculture and Animal Resources Development Board (Rubona Station) during the 2018/2019 cropping season. Analysis of variance (ANOVA) was used to determine whether differences between treatments were statistically significant, with the threshold for statistical significance set at $p < 0.05$. Aboveground biomass differed significantly between treatments, with maximum and minimum values of 11,475 kg and 7,850 kg, respectively, being observed. Furthermore, the harvest index differed significantly between treatments, with minimum and maximum values of 0.2136 and 0.33, respectively, being observed. Grain yield also differed significantly between treatments, with the highest value (3,053 kg/ha) observed for a treatment which applied liquid and granular fertilizer at equal proportions (treatment 8), and the lowest one was found in treatment 3 with 1,852 kg/ha. In this study, the gap between the lowest and highest grain yields was about 39.3%. In conclusion, the combination of organic liquid fertilizer and granular fertilizer can significantly increase the grain yield of maize in Rwanda.

Title: Perinatal Rib Fractures in 18 Calves Delivered from Holstein Dams.

Authors: Ishiyama, D., Makino, E., Nakamura, Y., Uchida, M., Shimizu, H., Ono, M., & Horikita, T.

Journal: *Veterinary and Animal Science.* **Date:** 2020

DOI: https://doi.org/10.1016/j.vas.2020.100134

Cranial rib fractures during dystocia and the ensuing callus formations in calves often cause tracheal stenosis. Rib fractures may affect the lung since ribs tend to fracture above the costochondral junction during delivery. Considering that calving assistance rates for dystocia are high, calves with fractured ribs may develop respiratory disease, which results in economic loss.

The objective of this study was to elucidate the contribution of rib fractures to economic loss through respiratory disease in calves. Of 163 sick calves delivered from Holstein-Friesian dams included in this study, a total of 18 rib fractured calves was found, giving an incidence of rib fracture in sick calves of 11.0%. There were significant differences in incidence by the rib involved, indicating the 2nd to 7th ribs tend to break. Many of the rib-fractured calves showed dyspnea and pyrexia. In this study, four of five scanned or necropsied calves had pneumonia lesions despite the fact that these four calves did not have tracheal stenosis. Rib fractured calves sold at below market value with a median difference from average sale price of minus 64,861 yen. Survival analysis indicated an overall association between rib fracture and time to death. In this study, we demonstrated that rib fractures happened most frequently in the 2nd to 7th ribs, and these cases tended to cause pneumonia, which decreased sale prices and longevity. Farmers should work to reduce risks and rates of dystocia so as to lessen economic loss and poor welfare in calves due to rib fractures.

Title: Vitamin D: Acute Moderate-Intensity Exercise Increases Total Antioxidant Capacity and Anti-Inflammatory Responses in Competitive Cyclists: The Role of Adiponectin.

Authors: Jakus, T., Jurdana, M., Žiberna, L., & Pražnikar, Z. J.

Journal: *European Journal of Inflammation.* **Date:** 2021

DOI: https://doi.org/10.1002/jbm4.10554

High-intensity exercise can elicit acute changes in the biochemical and physiological processes in the body of an athlete, including increased oxidative stress and inflammation. The purpose of this study was to explore the effect of acute moderate-intensity exercise on total antioxidant capacity (TAC) and serum levels of anti-inflammatory adiponectin (APN), and inflammatory markers in competitive cyclists. Ten male cyclists (age 15–26 years, body mass index 19.4–24.7 kg/m2) participated in this study. Each subject performed the maximal oxygen uptake test (VO2peak) and completed a 10-min cycling exercise at a workload of 50% of the peak of VO2peak. Blood samples were collected on three different occasions: after an overnight fasting and at the exercise workloads of 50% and 100% VO2peak. We measured APN, TAC, inflammatory markers as well as assessed nutrient and energy intake for each participant. Baseline concentration of serum APN (10.92 μg/mL) significantly increased at 50% and at 100% VO2peak. In addition, TAC also increased after acute exercise (0.079 vs 0.093 nmol/μL). The concentration of APN at 50% VO2peak positively correlated with the CRP ($r = 0.640$, $p = 0.046$) and negatively correlated with TNF-α ($r = -0.696$, $p = 0.025$). This test showed that short (10 min) and medium-intensity (50% VO2peak) exercise activity in trained athletes evoked beneficial antioxidant and anti-inflammatory responses. Importantly, this response correlates with the increase in APN levels thereby showing that highly trained individuals have beneficial responses originating from adipose tissue. Our observations show that a short training at moderate activity can be an important preservative strategy during the recovery training period.

Title: Development and Physico-Chemical Characterization of Apple-Peach Fruit Leather.

Authors: Javaria, S., Marwat, A., Nadeem, M., Zerlasht, M., Kareem, A., Rubab, I., & Munir, M.

Journal: *Pakistan Journal of Agricultural Research.* **Date:** 2021

DOI: https://doi.org/10.17582/journal.pjar/2021/34.2.318.324

Fresh fruit leathers, a dehydrated snack have the potential to increase fresh fruit utilization especially in the children. The present investigation was designed to standardize the formulation of apple peach mixed fruit leather. Exact formulation has very important role in producing an acceptable and admired food product and the product grab more market. Therefore, the formulation of apple peach mix fruit leather was standardized by different treatments i.e. apple peach puree mixed in various combinations T1 (100:0), T2 (75:25), T3 (50:50), T4 (25:75), T5(0:75) to develop a nutritious functional snack. The effects of different fruit ratios on moisture content (MC), pH, total titratable acid content, total soluble solids (TSS), vitamin C, protein, iron and magnesium were investigated. Results of sensory evaluation showed that all the samples were in an acceptable range. However, Mix fruit leather with 50 % apple puree and 50% peach puree was liked the most by the panelists.

Title: Quality Attributes of Value Added Tarts Developed from Lotus (Nelumbo Nucifera) Seed Powder.

Authors: Kumari, J., & Arivuchudar, R.

Journal: *International Journal of Current Research and Review.* **Date:** 2021

DOI: https://doi.org/10.31782/IJCRR.2021.13111

The consumer preference for snack product is on a huge rise, which is evident from the increase in revenue generated by the snack food industries. Also, the increase in nutritional awareness has posed a demand to develop nutritious snack products for bingeing. The tarts are extremely attractive and relished high-calorie snack by people of all age groups. The lotus seed with pharmaceutical properties is underutilized and hence used in this study to balance the empty calories provided by tarts.

Title: Dietary Lifestyle Status of Adolescents: Analysis of Large-Scale Survey Data in Korea.

Authors: Lee, S. J., & Ryu, H. K.

Journal: *Journal of the Korean Society of Food Science and Nutrition.* **Date:** 2021

DOI: https://doi.org/10.5468/OGS.20230

This study analyzed the dietary conditions of Korean adolescents using the 2018 data from the Korea National Health and Nutrition Examination Survey (KNHANES), Korea Youth Risk Behavior Survey (KYRBS), and Consumer Behavior Survey for Food (CBSF). Totally, 397 (KNHANES), 60,040 (KYRBS), and 614 (CBSF) subjects were analyzed for this study. Subjects with normal weights were 69.0%, 73.0%, and 90.8%, respectively, and the rate of skipping breakfast was determined to be 31.8%, 33.6%, and 7.4%, respectively. The main reason for skipping meals was 'not having enough time (78.3%)', 45.2% of the subjects ate out more than 'once/week', 37.8% used the convenience store, and 51.9% ate out to eat delicious food. According to the KNHANES, the average food intake was 1,353.05 g/day, which differed in the amount of cereals, vegetables, seaweeds, oils and fat, and spices intake by gender. The nutrient intakes of energy, vitamin A, niacin, vitamin C, calcium, iron, dietary fiber and potassium were lesser than the recommended levels. Non-physical activity for more than 60 minutes a day per week was observed in 36.3~82.0% of the subjects. Drinking experience among adolescents was 33.5~42.3%, and the most popular frequency and amount of drinking were determined to be 'once/month' and '1~2 glasses', with almost no binge drinking reported. The experience of smoking was 14.9% for cigarettes, 7.9% for e-cigarettes, and 2.9% for heated tobacco, with 21.8% daily smokers, smoking an average of '2~5 cigarettes/day (30.9%)'. Subjects receiving nutrition education were 21.2~47.2%, with 95.8% having an awareness rate of nutrition labeling, but being implemented by a mere 33.2%.

Title: High Dietary Micronutrient Inadequacy in Peri-Urban School Children from A District in South India: Potential for Staple Food Fortification and Nutrient Supplementation.

Authors: Madhari, R. S., Boddula, S., Ravindranadh, P., Jyrwa, Y. W., Boiroju, N. K., Pullakhandam, R., Mamidi, R. S., Nimmathota, A., Kulkarni, B., & Thingnganing, L.

Journal: *Maternal and Child Nutrition.* **Date:** 2020

DOI: https://doi.org/10.1111/mcn.13065

Multiple micronutrient deficiencies (MNDs) co-exist, often because of poor intakes and adversely impact health. Habitual diets were assessed in 300 school children (6–17 years old) recruited from two government schools by simple random sampling. Probability of adequacy (PA) for 11 micronutrients and mean probability of adequacy (MPA) was calculated. Haemoglobin, plasma ferritin, folic acid, vitamin B12 and C-reactive protein were estimated. Descriptive statistics and regression analysis were used to estimate magnitude and factors associated with MNDs. The contribution of fortified foods and/or supplements in addressing inadequacies and excessive intakes was modelled. The PA ranged from 0.04 for folate to 0.70 for zinc, and the MPA was 0.27. Prevalence of anaemia (53%), iron deficiency (57%; ID), iron deficiency anaemia (38%; IDA), folate deficiency (24%) and B12 deficiency (43%) was high. Dietary inadequacy of iron, zinc and

a low MPA was associated with anaemia and IDA. Inclusion of double fortified salt (DFS), fortified rice (FR) or iron folic acid (IFA) supplements individually in habitual diet reduced probability of iron inadequacy significantly from 82% to ≤13%. Inclusion of DFS and FR simultaneously led to disappearance of iron inadequacy, but risk of excessive intake increased to 16%. Inclusion of DFS, FR and IFA together increased risk of excess iron intake to 40%. Nevertheless, intakes of folate and B12 remained inadequate even with FR and/or IFA. These results indicate a high risk of dietary MNDs in children and suggest need for more systematic intake measurements in representative sample and adjustment of iron dosages to avoid excessive intakes.

Title: Anemia in Elderly Women. Rational Prevention. Evidence Base.

Authors: Markova, E. A., Khashukoeva, A. Z., Khlynova, S. A., Burdenko, M. V., & Karanasheva, A. K.

Journal: *Meditsinskiy Sovet.* **Date:** 2021

DOI: https://doi.org/10.21518/2079-701X-2021-3-128-134

Iron deficiency anemia is a frequent companion in postmenopausal women and those who have reached adulthood. Anemia in mild form in elderly women often occurs almost asymptomatically. Over time, iron deficiency progresses: severe complications occur, the quality of life decreases significantly, and the prognosis for life becomes unfavorable. A cross-section of the literature data in recent years shows that iron, folate, vitamin B12 deficiency, gastrointestinal diseases, pathologies in the processes of erythropoiesis and other somatic diseases come to the fore in terms of the etiological factors of anemia in elderly women. An important role in the development of anemia in older women is played by an irrational diet throughout life, which causes a lack of iron and folate in food. That is why therapy with a complex drug, which includes iron (II) fumarate in combination with folic acid is a rational choice in comparison with iron monotherapy for the prevention and treatment of anemia in elderly women. The administration of oral iron preparations for the correction of iron deficiency and for the purpose of selecting an effective pathogenetic therapy for anemia solves the problem of complications and improves the quality of life of older women. Iron (II) fumarate + folic acid - a tablet form of iron preparation in combination with folic acid for oral use, which has good tolerability, quickly replenishes iron reserves in the body of elderly patients, reducing mortality in this age group.

Title: Effect of Milk-Based Infant Formula Fortified with Pufas on Lipid Profile, Growth and Micronutrient Status of Young Children: A Randomized Double-Blind Clinical Trial.

Authors: Rivera-Pasquel, M., Flores-Aldana, M., Parra-Cabrera, M. -. Quezada-Sánchez, A. D., García-Guerra, A., & Maldonado-Hernández, J.

Journal: *Nutrients.* **Date:** 2021

DOI: https://doi.org/10.3390/nu13010004

Abstract

Background: Polyunsaturated fatty acids (PUFAs) are essential to child growth and development. Objective: To assess the effect of PUFAs-fortified infant formula on lipid profile, growth and micronutrient status in children 12 to 30 months old. Methods: This study is a double-blind randomized controlled clinical trial. Two study groups were assessed: (a) milk-based infant formula with micronutrients and PUFAs (PUFAs) and (b) milk-based infant formula with micronutrients, no PUFAs added (Non-PUFAs). Children received prepared formula (240 mL) twice a day, according to the color-code assigned to each infant. Anthropometric measurements and venous blood samples were taken at each day-care center at baseline, and again after four months. Total serum lipid extraction was 0.5 mL. Samples were treated and modified by the Folch method and analyzed with gas chromatography. Results: Changes in serum lipid profile (expressed as % FA) between baseline and four months showed a statistically significant increase in docosahexaenoic acid (DHA) (0.22 vs. −0.07, $p < 0.05$) and Alpha-Linoleic acid (0.08 vs. 0.02, $p < 0.05$) in infants who consumed PUFAs-fortified formula compared to Non-PUFAs-fortified formula. Infants increased their length/height-for-age Z-score: median change for the PUFAs group was 0.16 (95% CI = 0.08, 0.28) and 0.23 (95% CI = 0.14, 0.33) for Non-PUFAs, with no differences between groups. Median folate level was significantly higher among the PUFAs group compared to Non-PUFAs: −0.87 (95% CI = −1.38, −0.44) and −3.83 (95% CI = −4.65, −3.03) respectively. Consumption of both supplements was adequate and stable during the intervention. Conclusion: A significant improvement was observed in the lipid profile of children who received the PUFAs-fortified milk-based formula.

Keywords: **DHA**; **PUFAs**; **lipids**; **infant formula**; **micronutrients**

1. Introduction

Dietary lipids, especially long-chain polyunsaturated essential fatty acids (LCPUFAs), have received attention in the last several decades due to their influence on health [**1**]. During pregnancy and lactation, N-3 fatty acid (α-linolenic acid (ALA), eicosapentaenoic acid (EPA)) and docosahexaenoic acid (DHA) have been linked to length of gestation, preterm birth, birth weight, and postpartum depression [**2**]. During infancy and childhood, they have been associated with postnatal growth, cognitive and visual development, and allergies [**3**]. These essential fatty acids

can be found mainly in oil-rich fish, breast milk, and algae [4]. The amount of essential fatty acids in human milk is determined mainly by the regular consumption of oil-rich fish, algae, and supplements during pregnancy and lactation [5].

The fatty acid profile can be influenced by maternal dietary habits and body stores [6]. A study carried out in pregnant Mexican women showed low intakes of preformed DHA, where median intake was 55 mg/day [6]. It is known that in pregnant and lactating women circulation levels of polyunsaturated essential fatty acids (PUFAs) are transferred to the fetus and infant through the placenta and/or mammary glands. Low levels of PUFAs may compromise maternal stores [7]. According to the National Health and Nutritional Survey-2006 in Mexico, more than 50% of the population (all ages) does not meet the recommended dietary intake of PUFAs. Median consumption of DHA and EPA were 30 mg/day [8].

Infants and children also suffer from micronutrient deficiencies, which have adverse effects on survival, growth, and development. The principal comorbidities include congenital defects, blindness, and greater susceptibility to infections, cognitive impairment, and premature mortality [9]. The most common micronutrient deficiencies worldwide among infants and young children are those related to vitamin A, folates, zinc, and fatty acids [9]. The estimated global prevalence of vitamin A deficiency in children <5 years of age is about 30% [10], while the prevalence of zinc deficiency in pre-school-age children is 17.4% [9]. Recent studies have shown vitamin D deficiency (25-OH-D < 50 nmol/L) in 33% of pre-school and school-age children [11]. In Mexico, the most prevalent nutrient deficiencies in children <5 years old include: iron (26%), zinc (28%) and anemia (20.6%), followed by moderate deficiencies in vitamin B12 (7.3%) and folic acid (3.6%) [12].

During infancy, it is difficult to reach the requirements of essential fatty acids and certain micronutrients. Many interventions have been implemented to improve LCPUFA and micronutrient status in children [9,13]. Supplementation and food fortification have been used to increase fatty acid and micronutrient consumption [9]. Many food vehicles include cereals, porridges, micronutrients powders, lipid-based nutrient supplements, and fortified milk [13].

A recent study in Mexico showed a decrease in the prevalence of anemia and iron deficiency in children 12 to 30 months who received iron-fortified milk as part of the national program Leche Industrializada Conasupo S.A. (LICONSA) [14]. This study led to the scaling up of a subsidized fortified milk distribution program, which benefits 4.2 million children from ages one to 11 years in Mexico [14]. Milk is an efficient vehicle because it is widely accepted by children and easy to prepare [14].

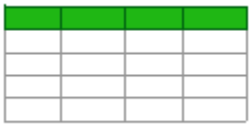
The main objective of this study is to assess the effect of PUFAs-fortified milk-based infant formula on lipid levels in Mexican infants 12 to 30 months old. Moreover, anthropometry and micronutrient status of the infants were evaluated.

2. Materials and Methods

2.1. Study Design and Intervention

This is a double-blind, randomized controlled trial with two treatment groups: (a) milk-based infant formula with micronutrients and PUFAs (PUFAs) and (b) milk-based infant formula with micronutrients only, and no PUFAs added (Non-PUFAs) (**Table 1**). The intervention period lasted for four months. The study was conducted in 2012–2013 in day-care centers in Cuernavaca, Morelos. The study was approved by the Ethics, Research, and Biosecurity Committees of the National Institute of Public Health in Mexico (in Spanish, INSP) (CONBIOÉTICA: 17CEI00120130424). Written informed consent for study participation was obtained from subjects' parent or caregiver. Formula was provided free of charge to the parents/caregivers even if they dropped out of the study or did not want to participate. Parents/caregivers did not receive compensation for participation. Parents/caregivers received information on their child's health and nutritional assessment. Recommendations on an adequate diet were provided at the end of the study. Parents/caregivers read the informed consent. If parents/caregivers accepted to participate in the study, they and a witness signed the informed consent. A copy of the signed informed consent was provided to parents/caregivers. Trial registration was obtained by Clinical Trials U.S. National Institutes of Health, NCT03397485 on 14 September 2017.

Table 1. Nutrient composition of study formulas by treatment group.



2.2. Population and Setting

Infants were recruited at 12 day-care centers in Cuernavaca, Morelos, México. Eligible infants were 12 to 30 months old, healthy, and whose parents/caregivers consented to study participation. The day-care centers were part of a national government program whose main objective was to support working mothers and single parents. Exclusion criteria were infants who were breastfed at the time of the study, infants receiving other milk with micronutrients, and those who were clinically sick. A hemoglobin screening test was conducted, and infants with capillary hemoglobin concentration <9.0 g/dL were excluded and referred for treatment at a local health center.

The study protocol was explained to the day-care directors, who agreed to participate. Each director made appointments with parents/caregivers at each day-care center. The project coordinator and a scientist-researcher explained the objective and methods of the study. At these appointments, parents/caregivers were invited to participate.

2.3. Randomization and Masking

The Moses Oakford method [**15**] was used to randomly assign each infant to one of the two groups to receive either milk-based infant formula with PUFAs (PUFAs), or a formula with micronutrients only (Non-PUFAs). The cans of formula were numbered consecutively to follow the random assignment. Both infant formulas had the same color (white milk powder), odor, and flavor, and were indistinguishable except for the color-coding of the can. A four-color code was used, two for each treatment: red & gray for the PUFAs treatment, and blue & green for the Non-

PUFAs treatment. The color code was unknown to researchers, field workers, users, and analysts until the study ended. The manufacturer logo was not identifiable on the cans.

2.4. Product Preparation and Volume Intake

Milk-based infant formula was prepared Monday through Friday at each day-care center by trained personnel according to World Health Organization (WHO) guidelines. Formulas were reconstituted with 240 mL of purified water and eight spoonfuls of milk powder (5 g each spoonful; 40 g total powder). Formula was prepared in the bottles, then weighed using a measuring scale. Both groups received 480 mL per day: 240 mL at 7:00 a.m. and 240 mL at 4:00 p.m. Leftover formula was weighed using a measuring scale and recorded on a consumption form by the study personnel.

On weekends, parents/caregivers were instructed on how to prepare powdered milk infant formula according to WHO guidelines [**16**]. Study personnel provided them with the amount of infant formula necessary to prepare 480 mL per day over the weekend. They were trained to estimate and record infant formula consumption on a form with a sketch of an 8-ounce bottle marked for volume. This was also the case for infants who drank formula before arriving to the day-care center early in the morning. On Mondays, parents/caregivers handed in the consumption form to the project supervisor.

2.5. Outcomes

The main objective of the study was to assess the effect of milk-based infant formula fortified with PUFAs and micronutrients on lipid status between study enrollment and four months, as compared to milk-based formula with micronutrients only. Lipid profile included fatty acids with a chain length between 12 and 22 carbon atoms. Growth and micronutrient status were also assessed.

2.6. Measurement of Blood Samples

At the day-care centers, blood samples were obtained by two trained nurses according to protocol procedures established by the Biosecurity Commission at the National Institute of Public Health in Mexico (INSP).

Hemoglobin concentration was taken only at baseline for screening procedures, and was determined in capillary blood samples obtained by finger prick and measured in a Portable Photometer—Hemocue [**17**]. Cutoff points for anemia were defined according to WHO standards [**18**] and adjusted by altitude [**19**]. A 10 mL venous blood sample was also obtained from the antecubital vein at baseline, and at 4 months thereafter. Venous samples were centrifuged, using a portable centrifuge EBA8 (Hettich, Tuttlingen, Germany) at 280× *g*; 20 min in situ and serum was separated and stored in color-coded cryovials, preserved in liquid nitrogen until delivery to a central laboratory in Cuernavaca, Mexico and stored at −70 °C until defrosted for analyses.

2.7. Fatty Acid Profile

For extraction of total lipid content, 0.5 mL of plasma was treated with the modified Folch method [**20**]. Analysis was performed with a gas chromatograph 7820A (Agilent Technologies, Santa Clara, CA, USA) with a flame ionization detector (FID). Fatty acids were separated using a HP-88 capillary column (100 m × 0.25 mm ID; Agilent Technologies, Inc., USA). PUFAs ranging

from 12–22 chain length carbon atoms and peaks were identified by comparing their retention times with those of high purity (>99%) standard mixtures (Sigma-Aldrich Chemie GmbH, 37 FAs mixture). Results were expressed as a percentage of all fatty acids detected with a chain length between 12 and 22 carbon atoms [21,22].

2.8. Micronutrients

Serum concentrations of ferritin (µg/L) were measured by an immunoassay method using commercial kits (Dade Behring Inc., Deerfield, IL, USA), while concentrations of zinc (µg/dL) were determined by atomic absorption spectrometry using an Analyst 300 spectrometer (Perkin-Elmer, Norwalk, Ct, USA) [23]. Folate (ng/mL) was transformed into cyanocobalamin and stable folates. Concentrations were measured by Toyo Soda Manufacturing Company (TOSOH) automated immunoanalyzer [24]. Vitamin D measured through 25-OH-D3 (nmol/L) was analyzed by chemiluminescent microparticle immunoassay (CMIA) using an Abbott Architect module [25,26]. Vitamin A (µg/dL) determinations were performed by high-performance liquid chromatography (HPLC) in a Waters instrument (Waters Co., Milford, MA, USA) [27].

2.9. Anthropometric Measurements

Anthropometric measures were taken at baseline, 8 weeks, and 16 weeks. Weight was measured to the nearest 10 g with an electronic scale (Tanita Scale, Tanita Corp., Arlington Heights, IL, USA, capacity 14 kg for infants and 36 kg adults, Tokyo, Japan) and length/height were measured to the nearest millimeter with a length board (Schorr Industries, Glenn Burney, MD, USA). Weight and length were transformed to Z-scores using the 2006 WHO reference standards [28]. Stunting was defined as a length for age Z-score < − 2 SD; underweight as weight for age Z-score < −2 SD; wasting as weight for length/height Z-score < −2 SD, and overweight or obesity as body mass index (BMI) for age Z-score > +2 SD [28].

2.10. Dietary Assessment

Dietary information was collected with a 7-day semi-quantitative food frequency questionnaire (SFFQ). Trained health personnel administered the SFFQ. In an interview, parents/caregivers were asked to recall the number of days of the week, times-a-day, and portion sizes that their children consumed over a 7-day period, based on standard and home-made measurements, as well as the number of portions consumed for each food item. Foods included in the questionnaire represented 95% of the total dietary consumption of pre-school-age children, according to a single 24 h recall questionnaire from the 1999 Mexican National Nutrition Survey (ENN-99) [29]. Thirty nine new foods were added to the Encuesta Nacional de Salud y Nutrición 2006 (ENSANUT-2006), some of which were adopted for use in the SFFQ. These foods and dishes were commonly consumed, and were classified according to fat, sugar and sodium content [24]. A group of experts in nutrition from the Center for Nutrition and Health Research in the National Institute of Public Health in Mexico selected the items used in the SFFQ, which included 123 foods and beverages. Consumption of foods was expressed in grams (g) or milliliters (mL) in one day. Consumption was calculated according to frequency, portion size (g or mL), and number of portions at each meal divided by seven days of the week. The following step was to convert the amount (g or mL) of each item into energy and nutrients using a food composition table, which was created by the National Institute of Public Health in Mexico [30].

2.11. Formula Intake

For each participant, total formula intake was divided by total days of study participation. The median of this individual average consumption was calculated and compared over the analysis sample for each study group. Bias-corrected bootstrap 95% confidence intervals for these statistics were obtained with 1000 replicates through stratified resampling by study group.

2.12. Sociodemographic Characteristics

Study population characteristics were obtained at baseline by interviewing the parents/caregivers. A socioeconomic index was constructed through principal component analysis using household conditions (floor and roof material), services and basic household infrastructure (e.g., sources and disposal of water availability of toilet, and gas stove) to create a score [**31**]. The first principal component explained 30% of total variance.

2.13. Morbidity

Parents were asked to provide information on their infant's health on Monday, Wednesday and Friday. The question asked for diarrhea was: Did your infant have diarrhea yesterday? The question asked for respiratory tract infection was: Did your infant present cough, flu, or cold symptoms yesterday? If the infant presented more than three watery stools a day, he or she was sent to the nearest health center and the parent was asked to stop using the formula.

2.14. Sample Size

We approached the statistical power calculation by simulation with 1000 replicates by way of a median regression model and assuming a Gaussian distribution for the outcome in each study group. Given a total sample size of $n = 180$ (90 observations per group), this study achieved a statistical power of 80.7% to detect a median difference of 0.54 in standardized units.

2.15. Statistical Analysis

Baseline characteristics were compared between study groups through descriptive statistics. For continuous variables, the median, 25th and 75th percentiles were calculated. For categorical variables, frequencies and percentages were calculated for each category. Median changes in outcome variables and their difference between study groups were estimated through median regression using change in outcome as dependent variable, and an indicator variable of study group (0 = Non-PUFAs, 1 = PUFAS) as predictor. Median change for each study group was calculated with the appropriate linear combination of model coefficients and differences between study groups were calculated with the model coefficient of the study group indicator variable. Covariate-adjusted median change was obtained by adding the baseline measurement of the outcome and an indicator variable of sex (0 = male, 1 = female) as predictors. Covariate-adjusted median change for each study group was obtained with the appropriate linear combination of model coefficients by setting the baseline measurement predictor at its median and the sex indicator variable at its mean value for the whole sample, which corresponds to the proportion of female children. Standard errors were obtained by bootstrap resampling within each study group with 1000 replicates [**32**]. Bias-corrected 95% confidence bootstrap intervals were obtained for all estimates. Given the importance of the first 1000 days of life of a child, median regression models included

an interaction between study group and age group to detect whether the effects on fatty acids varied between age groups (<24 months, 24–33 months); interactions of age group with the other predictors were also included. Stata® IC 16.1 was used for all analyses (Stata Corp. 2019, Stata Statistical Software, College Station, TX, USA).

3. Results

The number of children assessed for eligibility were 271. A total of 232 healthy infants were randomized to receive the PUFAs-fortified or non-PUFAs-fortified formula. A total of 19 (16.1%) infants from PUFAs group and 20 (17.5%) in Non-PUFAs withdrew before the end of the study. The main reason for dropout was mothers refusing a second blood sample from their infant. In the group of 193 children who completed the study, 99 (51.3%) were assigned to the PUFAs group and 94 (48.7%) to the Non-PUFAs group. (**Figure 1**).

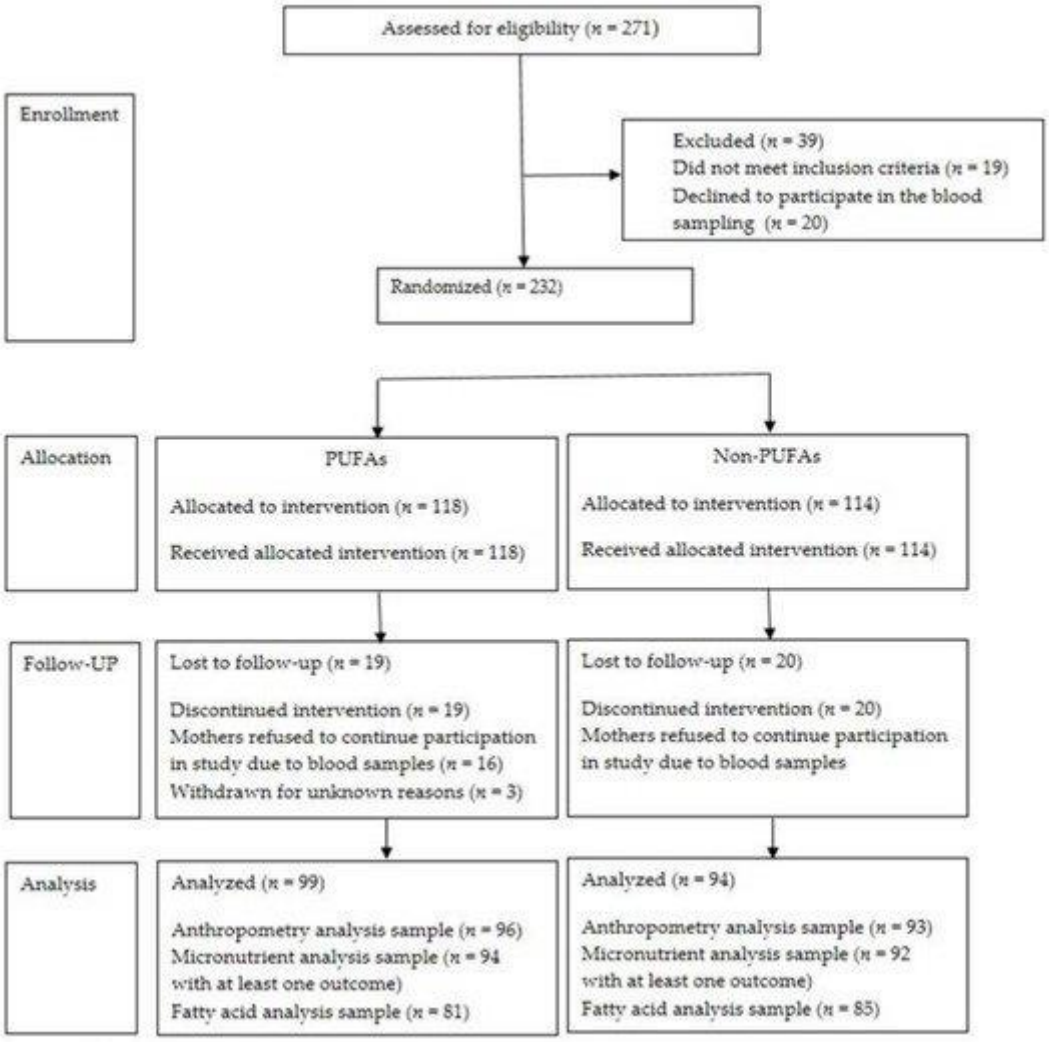


Figure 1. Flow of study subjects. Formula PUFAs contained vegetable oil (palm oil, coconut, soy and high oleic sunflower oils). DHA from fish origin, Linoleic Acid, Alpha-Linolenic Acid.

Morbidity information included diarrhea and acute respiratory infection. PUFAs: Milk-based infant formula with polyunsaturated fatty acids, Non-PUFAs: Formula with micronutrients only non polyunsaturated fatty acids.

Both formulas were well accepted by the infants. The median average PUFAs intake over the days of observation was 440 mL (95% CI = 425, 462), and 421 mL (95% CI = 409, 448) for the Non-PUFAs formula group, with no significant difference between study groups (19 mL; 95% CI = −14, 44). The proportion of infants that reported diarrhea was 42.9% for PUFAs and 57.1% for Non-PUFAs (p = 0.498), and the proportion of infants with respiratory tract infection was 54.7% for PUFAs and 45.3% for Non-PUFAs (p = 0.384).

Baseline characteristics for each treatment group are presented in **Table 2**. In general, these characteristics were balanced between study groups except for sex; 60.6% were male in the PUFAs group whereas 47.9% were male in the Non-PUFAs group.

Table 2. Baseline characteristics of infants who completed the study, by treatment group.

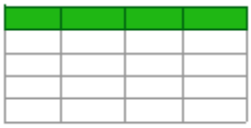


Table 3 shows median changes in percentage points (p.p.) of total whole-blood fatty acids (FA) from the serum lipid profile between baseline and after four months by treatment group, adjusted by sex and baseline measurement of the outcome. The PUFAs group showed significantly higher median change compared to the Non-PUFAs group for DHA (+0.29 p.p.), and Alpha-Linolenic acid (+0.06 p.p.).

Table 3. Covariate-adjusted [a] median change for FA% between baseline and after four months, by treatment group.

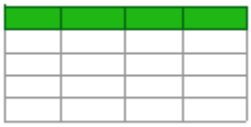
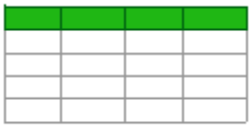


Table 4 shows the median change in anthropometry and micronutrient outcomes for infants between baseline and after four months by treatment group, adjusted by sex and baseline measurement of the outcome. In both groups more than 50% of infants increased their length/height-for-age Z-score, with median change of 0.16 (95% CI = 0.07, 0.26) in the PUFAs group, and 0.23 (95% CI = 0.14, 0.33) for the Non-PUFAs group, and with no significant difference between treatment groups. As for micronutrients, median change of folate was significantly higher in the PUFAs group at −0.87 (95% CI = −1.38, −0.44), compared to the Non-PUFAs at −3.83 (95% CI = −4.65, −3.03), wherein a statistically significant difference of 2.96 (95% CI = 2.02, 3.84) was seen between the PUFAs and Non-PUFAs groups (**Table 4**).

Table 4. Covariate-adjusted median changes [a] of anthropometric and micronutrient outcomes between baseline and after four months, by treatment group.



Analysis of the variation of treatment effects on FA by age group (<24 months and 24–33 months) showed no statistically significant differences in covariate-adjusted models ($p > 0.258$), nor in models without adjustment covariates ($p > 0.185$).

4. Discussion

This double-blind, randomized controlled trial shows that infants consuming a milk-based formula containing PUFAs for four months significantly increased their percentage levels of DHA and alpha-linolenic acid compared with those who consumed Non-PUFAs-fortified formula. Anthropometrical outcomes showed that infants in both groups slightly increased in length/height-for-age Z-score, although the difference was not statistically significant. Micronutrient composition within each group differed in that folate levels were significantly higher in infants from the PUFAs group as compared to their counterparts.

These results reflect those reported in previous studies. In one double-blind, controlled randomized trial carried out in healthy term infants, researchers evaluated the impact of three different infant formulas containing a mix of dairy fat and plant oils, only plant oils, or plant oils supplemented with DHA and ARA (arachidonic acid from the omega-6 family) for a period of four months. The formula containing dairy lipids fortified with PUFAs significantly increased total serum membrane omega-3 levels [**33**]. Birch et al. conducted a double-masked, randomized trial with four infant formulas containing equal amounts of nutrients, but in different dosages of PUFAs: 0% DHA, or 0.32% DHA, 0.64% DHA and 0.96% DHA, over a 12-month period. Red blood cell (RBC) DHA concentrations were significantly different (<0.001) between all formula groups at both four and 12 months of age, and RBC DHA concentration increased as formula DHA dosage increased [**34**]. In an observational study which compared RBC membrane fatty acids in infants supplemented with DHA and ARA with other types of milk, results showed that infants consuming supplemented formula had significantly higher levels of DHA and other omega-3s, as well as lower levels of omega-6 fatty acids in RBC membranes, than infants consuming non-supplemented formula [**35**].

These studies have shown that DHA serum concentrations significantly increased in pre-school-age children who receive an infant formula supplemented with PUFAs [**33**,**34**,**35**]. Our results support the critical importance of PUFAs supplementation during infancy. One reason is that, in developing countries, there is a low consumption of foods rich in PUFAs, such as oil-rich fish [**8**]. Second, studies have shown that particularly during infancy, it is difficult to meet dietary PUFAs requirements [**9**,**13**]. Third, between the ages of six months and three years, infants may

experience infantile anorexia nervosa, an eating disorder with onset during the early developmental stage of separation and individualization [**36**], wherein the infant refuses to eat in an attempt to achieve autonomy and control with regard to the mother [**36**].

Previous results of anthropometry and consumption of formulas rich in DHA are in accordance with our study. In Mexico, in a cohort study begun in 2006 and continuing to the present, pregnant women are given 400 mg/day of algal DHA and a soy and corn oil-based placebo for the last six months of pregnancy. Findings have shown no overall impact of DHA on infant weight and height at 18 months of age [**37**]. However, the study observed that among primigravid women who received DHA supplementation, infant length at 18 months did significantly increase 0.72 cm (95% CI = 0.11, 1.33), representing 0.26 length-for-age Z-score units [**37**]. The same study assessed prenatal supplementation with DHA on infant's weight, length and body mass index through 60 months of age. Results showed no significant differences by treatment group for these anthropometric measurements at 60 months of age (all $p > 0.05$) [**38**]. On the other hand, a study carried out in the United States on healthy singleton term infants who received either infant formula supplemented with LCPUFAs or a placebo formula were re-enrolled at 18 months and given follow-up by anthropometric assessment until six years of age. Results at 18 months of life showed that infants fed LCPUFA-supplemented formula had significantly greater linear growth than their counterparts [**34**]. From two to six years of age, LCPUFA-supplemented infants had significantly greater height for age than their counterparts [**39**].

Results of growth after supplementation with PUFAs are not conclusive. Most studies justify the addition of PUFAs to infant formula citing vision and cognitive development [**40**]. Nonetheless, only length and weight have been reported as outcome indicators [**40**]. These studies have shown that supplementation of PUFAs during pregnancy, lactation and early infancy may improve birth weight, weight and length for infants in developing countries [**40**]. In children above two years of age, no benefits of PUFAs consumption through infant formula on growth were observed in studies from developed and developing countries [**40**]. There is little evidence on the effect on PUFAs supplementation in children above two years of age. There is a need to continue studying this age group [**40**].

Median change in folate serum concentration was significantly higher in the PUFAs infant formula group. This may be explained by high compliance levels during the trial and because the PUFAs infant formula had four times more folic acid than Non-PUFAs infant formula. PUFAs infant formula also contained vitamin B12, a co-factor which enhances folic acid status [**41**]. Therefore, folate serum concentration was significantly higher among the PUFAs formula group.

Strengths of our study include that it was a well-controlled supplementary feeding trial. There was high compliance to treatment, and milk-based formula was properly diluted according to guiding standards. Adherence to treatment was measured at the study site by daily logs and confirmed by the changes in lipid blood levels. The infant formula was also supplied free of charge to the participants, which encouraged adherence to the randomized dietary allocation. Anthropometry was measured with precision and accuracy by standardized personnel at all the day-care centers.

Dropout rate was lower than 20% during the four-month study period, and the proportion of these dropouts was balanced between groups. Each day-care center trained the personnel that supervised the amount of formula consumed by each child daily.

Our study had some limitations; the four months of follow-up could have been shorter. We did not measure mental or motor development in children. Finally, there was a lack of information on infants' gestational age.

5. Conclusions

In this double-blind, randomized clinical trial, a significant improvement was observed in the lipid profile of children who received infant formula enriched with micronutrients and PUFAs, compared to children who received formula fortified with micronutrients only. In both groups, infants increased their length/height-for-age Z-score. Studies are needed on the effect of PUFAs-fortified infant formula on neurodevelopment, cognitive function, behavior and health outcomes (i.e., immune response, overweightness) of children.

Author Contributions

Conception and design of the study, approval of the version of the manuscript to be published, M.F.-A.; Acquisition of data, drafting the manuscript and approval of the version of the manuscript to be published, M.R.-P.; Drafting the manuscript, analysis and interpretation of data, A.D.Q.-S., J.M.-H. and M.-S.P.-C. Drafting the manuscript, analysis and interpretation of data as well as revising the manuscript critically for important intellectual content, A.G.-G. All authors have read and agreed to the published version of the manuscript.

Funding

The funding source did not have access to the data and did not play any role in analysis, interpretation of results, and/or manuscript production. Funded by Mead-Johnson Nutrition.

Acknowledgments

The authors wish to thank Claidé Merlos Lucho for coordinating the field work.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. FAO. *Fats and Fatty Acids in Human Nutrition. Report on an Expert Consultation*; Food and Nutrition Paper; FAO: Geneva, Switzerland, 2008; pp. 10–14

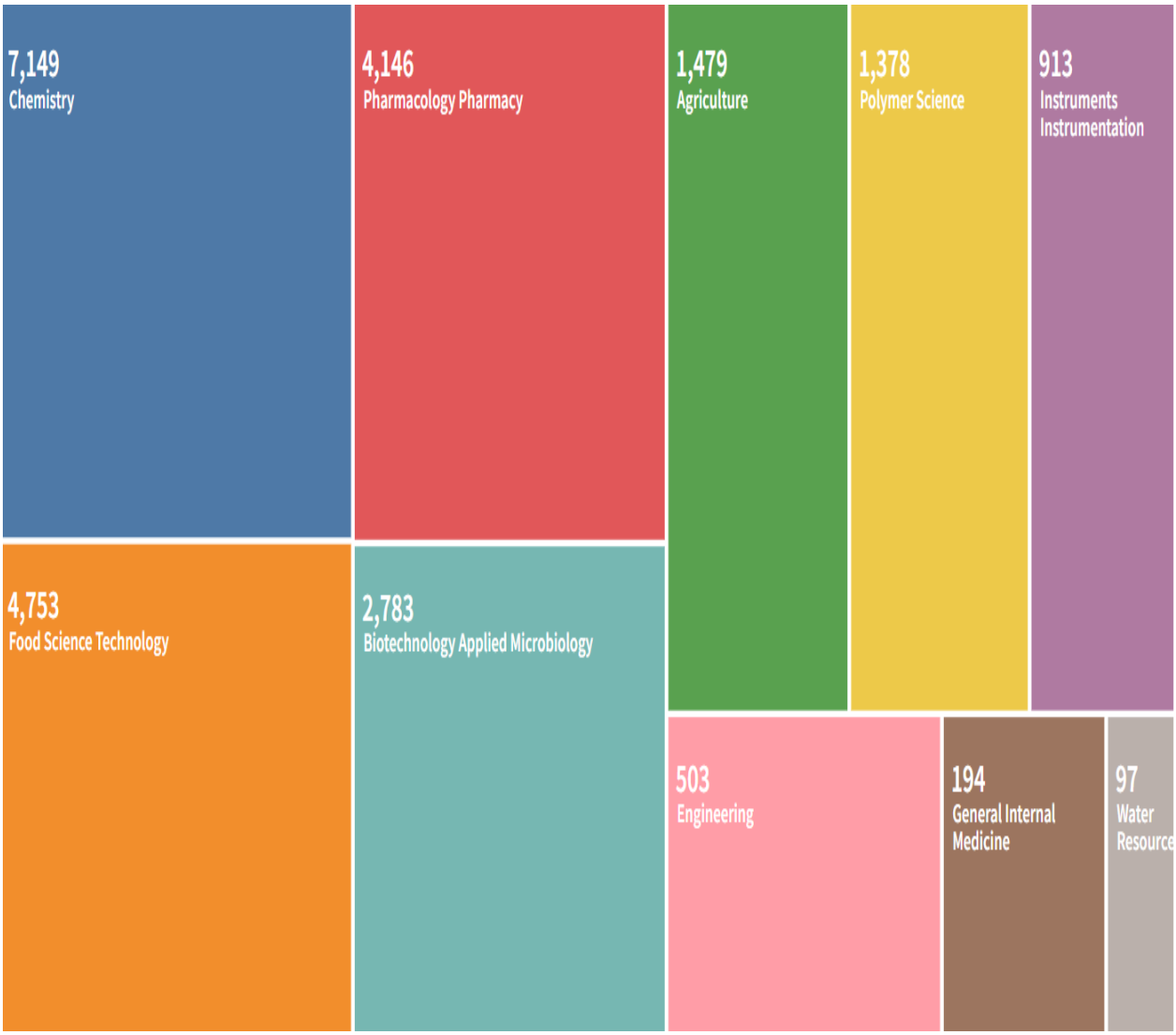
2. Shahidi, F.; Ambigaipalan, P. Omega-3 Polyunsaturated Fatty Acids and Their Health Benefits. *Annu. Rev. Food Sci. Technol.* **2018**, *9*, 345–381.
3. Ramakrishnan, U.; Gonzalez-Casanova, I.; Schnaas, L.; DiGirolamo, A.; Quezada, A.D.; Pallo, B.C.; Hao, W.; Neufeld, L.M.; Rivera, J.A.; Stein, A.; et al. Prenatal Supplementation with DHA Improves Attention at 5 Y of Age: A Randomized Controlled Trial. *Am. J. Clin. Nutr.* **2016**, *104*, 1075–1082.
4. Decsi, T.; Lohner, S. Gaps in Meeting Nutrient Needs in Healthy Toddlers. *Ann. Nutr. Metab.* **2014**, *65*, 22–28.
5. Koletzko, B.; Boey, C.C.; Campoy, C.; Carlson, S.E.; Chang, N.; Guillermo-Tuazon, M.A.; Joshi, S.; Prell, C.; Quak, S.H.; Sjarif, D.R.; et al. Current Information and Asian Perspectives on Long-Chain Polyunsaturated Fatty Acids in Pregnancy, Lactation, and Infancy: Systematic Review and Practice Recommendations from an Early Nutrition Academy Workshop. *Ann. Nutr. Metab.* **2014**, *65*, 49–80.
6. Parra-Cabrera, S.; Stein, A.D.; Wang, M.; Martorell, R.; Rivera, J.; Ramakrishnan, U. Dietary Intakes of Polyunsaturated Fatty Acids among Pregnant Mexican Women. *Matern. Child Nutr.* **2011**, *7*, 140–147.
7. Hornstra, G. Essential Fatty Acids in Mothers and Their Neonates. *Am. J. Clin. Nutr.* **2000**, *71*, 1262S–1269S.
8. Silva, I.R.; Villalpando, S.; Moreno-Saracho, J.E.; Bernal-Medina, D. Fatty Acids Intake in the Mexican Population. Results of the National Nutrition Survey 2006. *Nutr. Metab.* **2011**, *8*, 33.
9. Bailey, R.L.; West, K.P., Jr.; Black, R.E. The Epidemiology of Global Micronutrient Deficiencies. *Ann. Nutr. Metab.* **2015**, *66* (Suppl. 2), 22–33. [**Google Scholar**] [**CrossRef**]
10. Stevens, G.; E Bennett, J.; Hennocq, Q.; Lu, Y.; De-Regil, L.M.; Rogers, L.; Danaei, G.; Li, G.; A White, R.; Flaxman, S.R.; et al. Trends and Mortality Effects of Vitamin a Deficiency in Children in 138 Low-Income and Middle-Income Countries between 1991 and 2013: A Pooled Analysis of Population-Based Surveys. *Lancet Glob. Heal.* **2015**, *3*, e528–e536.
11. Flores, A.; Flores, M.; Macias, N.; Hernández-Barrera, L.; Rivera, M.; Contreras, A.; Villalpando, S. Vitamin D Deficiency Is Common and Is Associated with Overweight in Mexican Children Aged 1–11 years. *Public Health Nutr.* **2017**, *20*, 1807–1815.
12. Shamah-Levy, T.; Villalpando, S.; Jáuregui, A.; Rivera, J.A. Overview of the Nutritional Status of Selected Micronutrients in Mexican Children in 2006. *Salud Publica Mex.* **2012**, *54*, 146–151.
13. Keats, E.C.; Neufeld, L.M.; Garrett, G.S.; Mbuya, M.N.N.; Bhutta, Z.A. Improved Micronutrient Status and Health Outcomes in Low- and Middle-Income Countries Following Large-Scale Fortification: Evidence from a Systematic Review and Meta-Analysis. *Am. J. Clin. Nutr.* **2019**, *109*, 1696–1708.
14. Villalpando, S.; Shamah, T.; Dommarco, J.A.R.; Lara, Y.; Monterrubio, E. Fortifying Milk with Ferrous Gluconate and Zinc Oxide in a Public Nutrition Program Reduced the Prevalence of Anemia in Toddlers. *J. Nutr.* **2006**, *136*, 2633–2637.
15. Meinert, C.L.; Tonascía, S. *Clinical Trials. Design; Conduct an Analysis*; Oxford University: New York, NY, USA, 1968; pp. 95–112.
16. Organización Mundial de la Salud en Colaboración con la Organización de las Naciones Unidas Para la Agricultura y la Alimentación. *Preparación, Almacenamiento y Manipulación en Condiciones Higiénicas de Preparaciones en Polvo para Lactantes. Directrices*; Organización Mundial de la Salud: Geneva, Switzerland, 2007; pp. 1–26.

17. Hemocue, A.B. Fotómetro de Hemoglobina en Sangre. Manual de Operación. Suecia, Sweden 2003. Available online: **https://www.hemocue.com/es-es/soluciones-/hematolog%C3%ADa** (accessed on 14 July 2020).
18. Worldwide Prevalence of Anaemia 1993–2005 WHO Global Database on Anaemia. Available online: **https://apps.who.int/iris/bitstream/handle/10665/43894/9789241596657_eng.pdf?ua=1** (accessed on 14 July 2020).
19. Cohen, J.H.; Haas, J.D. Hemoglobin Correction Factors for Estimating the Prevalence of Iron Deficiency Anemia in Pregnant Women Residing at High Altitudes in Bolivia. *Rev. Panam. Salud Pública* **1999**, *6*, 392–399. [**Google Scholar**] [**CrossRef**] [**PubMed**][**Green Version**]
20. Folch, J.; Lees, M.; Stanley, G.H.S. A Simple Method for the Isolation and Purification of Total Lipides from Animal Tissues. *J. Biol. Chem.* **1957**, *226*, 497–509.
21. Martínez-Razo, G.; Martínez-Basila, A.; Salas-Fernández, A.; Maldonado-Hernández, J. Association between Metabolic Syndrome and Erythrocyte Fatty Acid Profile in Mexican Adolescents: ATrans Fatty Acid Approach. *Food Nutr. Sci.* **2013**, *4*, 51–58.
22. del Ayala-Moreno, M.R.; Fernández-Callejas, J.M.S.; Maldonado-Hernández, J. Assessment of Lipid Quality and Composition of Commercial Infant Milk Formulas in Mexico: Emphasis on Trans Fatty Acid Isomers. *Food Nutr. Sci.* **2016**, *7*, 273–283.
23. Tietz, N.W. (Ed.) *Clinical Guide to Laboratory Tests*, 3rd ed.; W.B. Saunders: Philadelphia, PA, USA, 1995; pp. 142–145. [**Google Scholar**]
24. Thorpe, S.J.; Heath, A.; Blackmore, S.; Lee, A.; Hamilton, M.; O'Broin, S.; Nelson, B.C.; Pfeiffer, C. International Standard for Serum Vitamin B12 and Serum Folate: International Collaborative Study to Evaluate a Batch of Lyophilised Serum for B12 and Folate Content. *Clin. Chem. Lab. Med.* **2007**, *45*, 380–386. [**Google Scholar**] [**CrossRef**] [**PubMed**]
25. National Institute of Standards & Technology. Certificate of Analysis. Standard Reference Material 968e. Fat-soluble Vitamins, Carotenoids, and Cholesterol in Human Serum. Department of Commerce USA. Available online: **https://www-s.nist.gov/m-srmors/certificates/968e.pdf** (accessed on 8 December 2020).
26. Bedner, M.; Lippa, K.A.; Tai, S.S.-C. An Assessment of 25-hydroxyvitamin D Measurements in Comparability Studies Conducted by the Vitamin D Metabolites Quality Assurance Program. *Clin. Chim. Acta* **2013**, *426*, 6–11.
27. Bieri, J.G.; Tolliver, T.J.; Catignani, G.L. Simultaneous Determination of α-Tocopherol and Retinol in Plasma or Red Cells by High Pressure Liquid Chromatography. *Am. J. Clin. Nutr.* **1979**, *32*, 2143–2149.
28. De Onis, M.; Onyango, A.W.; Borghi, E.; Siyam, A.; Nishida, C.; Siekmann, J. Development of a WHO Growth Reference for School-Aged Children and Adolescents. *Bull. World Health Organ.* **2007**, *85*, 660–667.
29. Ramírez-Silva, I.; Jiménez-Aguilar, A.; Valenzuela-Bravo, D.; Martinez-Tapia, B.; Rodríguez-Ramírez, S.; Gaona-Pineda, E.B.; Angulo-Estrada, S.; Shamah-Levy, T. Methodology for Estimating Dietary Data from the Semi-Quantitative Food Frequency Questionnaire of the Mexican National Health and Nutrition Survey 2012. *Salud Pública México* **2016**, *58*, 629–638.
30. Hernández-Ávila, J.E.; González-Avilés, L.; Rosales-Mendoza, E. *Manual de Usuario. SNUT Sistema de Evaluación de Hábitos Nutricionales y Consumo de Nutrimentos*; Instituto Nacional de Salud Pública: Cuernavaca, Mexico, 2013.
31. Gutiérrez, J.P. Clasificación Socioeconómica de los Hogares en la ENSANUT 2012. *Salud Publica Mexica* **2013**, *55*, S341–S346.

32. Efron, B.; Tibshirani, R. Better Bootstrap Confidence Intervals. In *An Introduction to the Bootstrap*; Chapman & Hall/CRC: London, UK, 1993; pp. 178–201.
33. Giannì, M.L.; Roggero, P.; Baudry, C.; Fressange-Mazda, C.; Galli, C.; Agostoni, C.; Le Ruyet, P.; Mosca, F. An Infant Formula Containing Dairy Lipids Increased Red Blood Cell Membrane Omega 3 Fatty Acids in 4 Month-Old Healthy Newborns: A Randomized Controlled Trial. *BMC Pediatr.* **2018**, *18*, 53.
34. Birch, E.; Carlson, S.E.; Hoffman, D.R.; Fitzgerald-Gustafson, K.M.; Fu, V.L.N.; Drover, J.R.; Castañeda, Y.S.; Minns, L.; Wheaton, D.K.H.; Mundy, D.; et al. The DIAMOND (DHA Intake And Measurement Of Neural Development) Study: A Double-Masked, Randomized Controlled Clinical Trial of the Maturation of Infant Visual Acuity as a Function of the Dietary Level of Docosahexaenoic Acid. *Am. J. Clin. Nutr.* **2010**, *91*, 848–859.
35. Miller, M.R.; Seifert, J.; Szabo, N.J.; Clare-Salzler, M.; Rewers, M.; Norris, J.M. Erythrocyte Membrane Fatty Acid Content in Infants Consuming Formulas Supplemented with Docosahexaenoic Acid (DHA) and Arachidonic Acid (ARA): An Observational Study. *Matern. Child Nutr.* **2010**, *6*, 338–346.
36. Chatoor, I. Infantile Anorexia Nervosa: A Developmental Disorder or Separation and Individuation. *J. Am. Acad. Psychoanal.* **1989**, *17*, 43–64.
37. Stein, A.D.; Wang, M.; Martorell, R.; Neufeld, L.M.; Flores-Ayala, R.; Rivera, J.A.; Ramakrishnan, U. Growth to Age 18 Months Following Prenatal Supplementation with Docosahexaenoic Acid Differs by Maternal Gravidity in Mexico. *J. Nutr.* **2011**, *141*, 316–320.
38. Gonzalez-Casanova, I.; Stein, A.D.; Hao, W.; Garcia-Feregrino, R.; Barraza-Villarreal, A.; Romieu, I.; Rivera, J.A.; Martorell, R.; Ramakrishnan, U. Prenatal Supplementation with Docosahexaenoic Acid Has No Effect on Growth through 60 Months of Age. *J. Nutr.* **2015**, *145*, 1330–1334.
39. Currie, L.M.; Tolley, E.A.; Thodosoff, J.M.; Kerling, E.H.; Sullivan, D.K.; Colombo, J.; Carlson, S.E. Long Chain Polyunsaturated Fatty Acid Supplementation in Infancy Increases Length- and Weight-for-Age but not BMI to 6 Years When Controlling for Effects of Maternal Smoking. *Prostaglandins Leukot. Essent. Fatty Acids* **2015**, *98*, 1–6.
40. Huffman, S.L.; Harika, R.K.; Eilander, A.; Osendarp, S.J.M. Essential Fats: How Do They Affect Growth and Development of Infants and Young Children in Developing Countries? A Literature Review. *Matern. Child Nutr.* **2011**, *7* (Suppl. 3), 44–65.
41. Strand, T.A.; Taneja, S.; Kumar, T.; Manger, M.S.; Refsum, H.; Yajnik, C.S.; Bhandari, N. Vitamin B-12, Folic Acid, and Growth in 6- to 30-Month-Old Children: A Randomized Controlled Trial. *Pediatrics* **2015**, *135*, e918–e926.

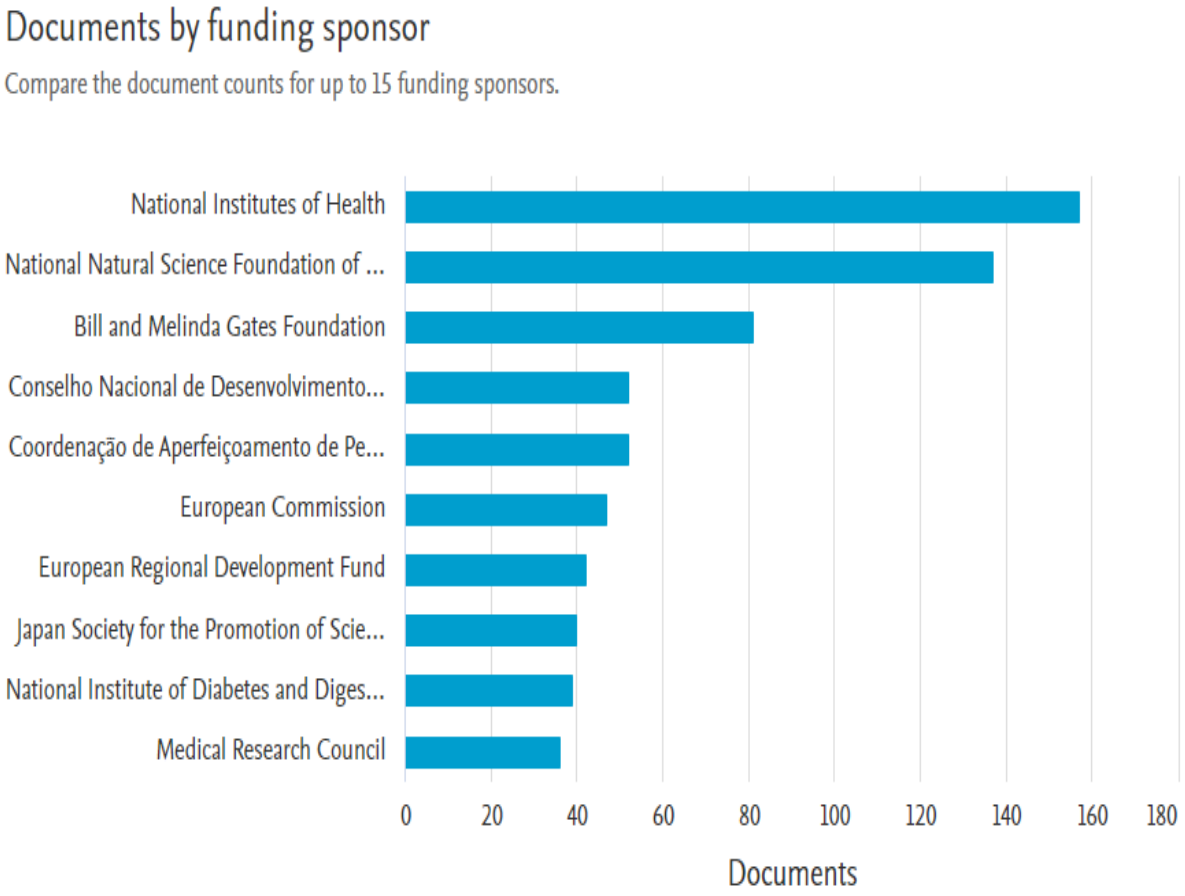
Patents Trends

Subject areas with the most number of patents on iron and vitamins



Funding Sponsors

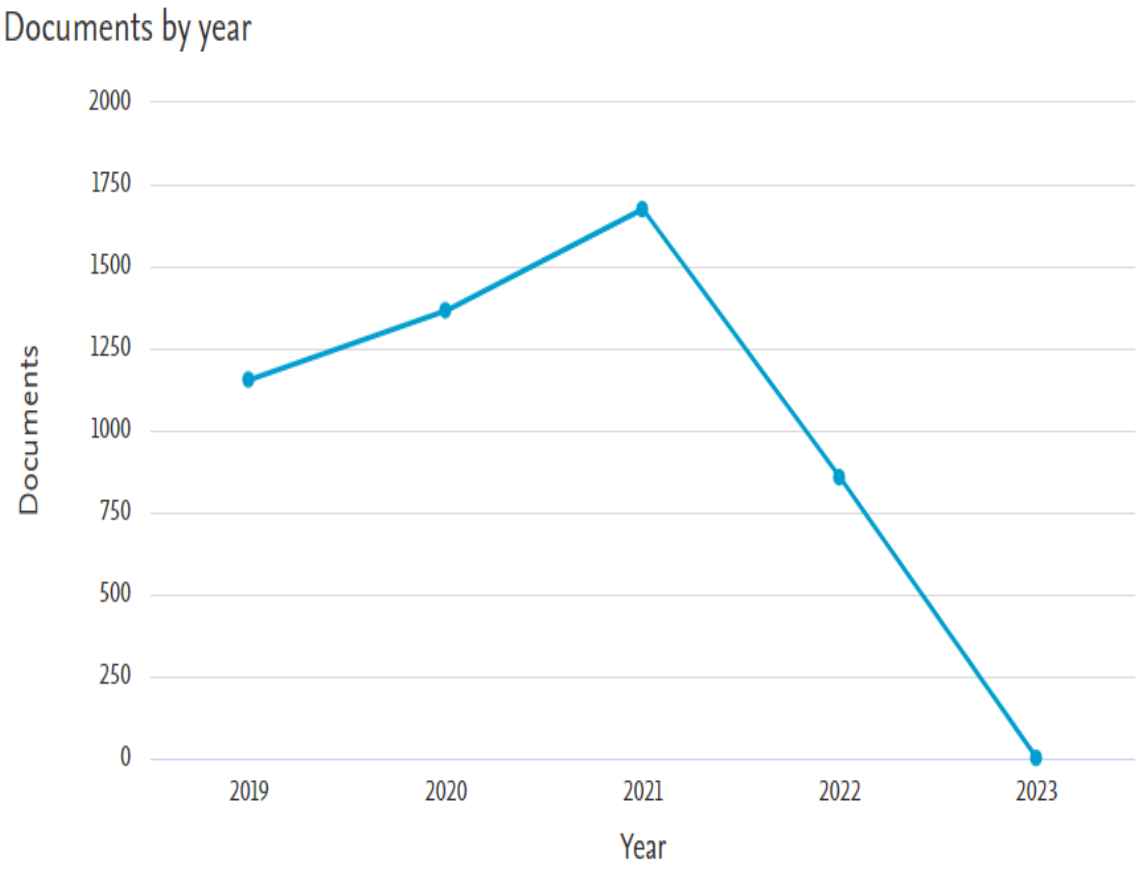
Funding sponsors who have published the most number of articles on iron and vitamins



Documents Trends

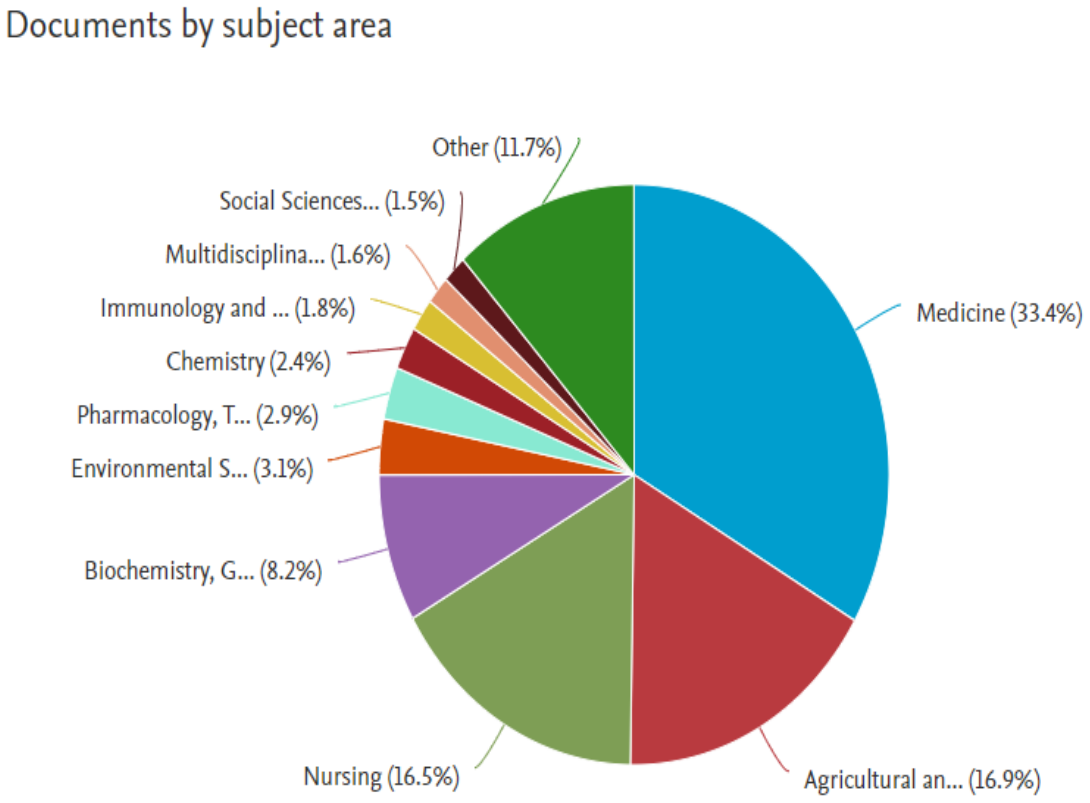
a) Documents per year:

Years of publishing the most number of documents on iron and vitamins



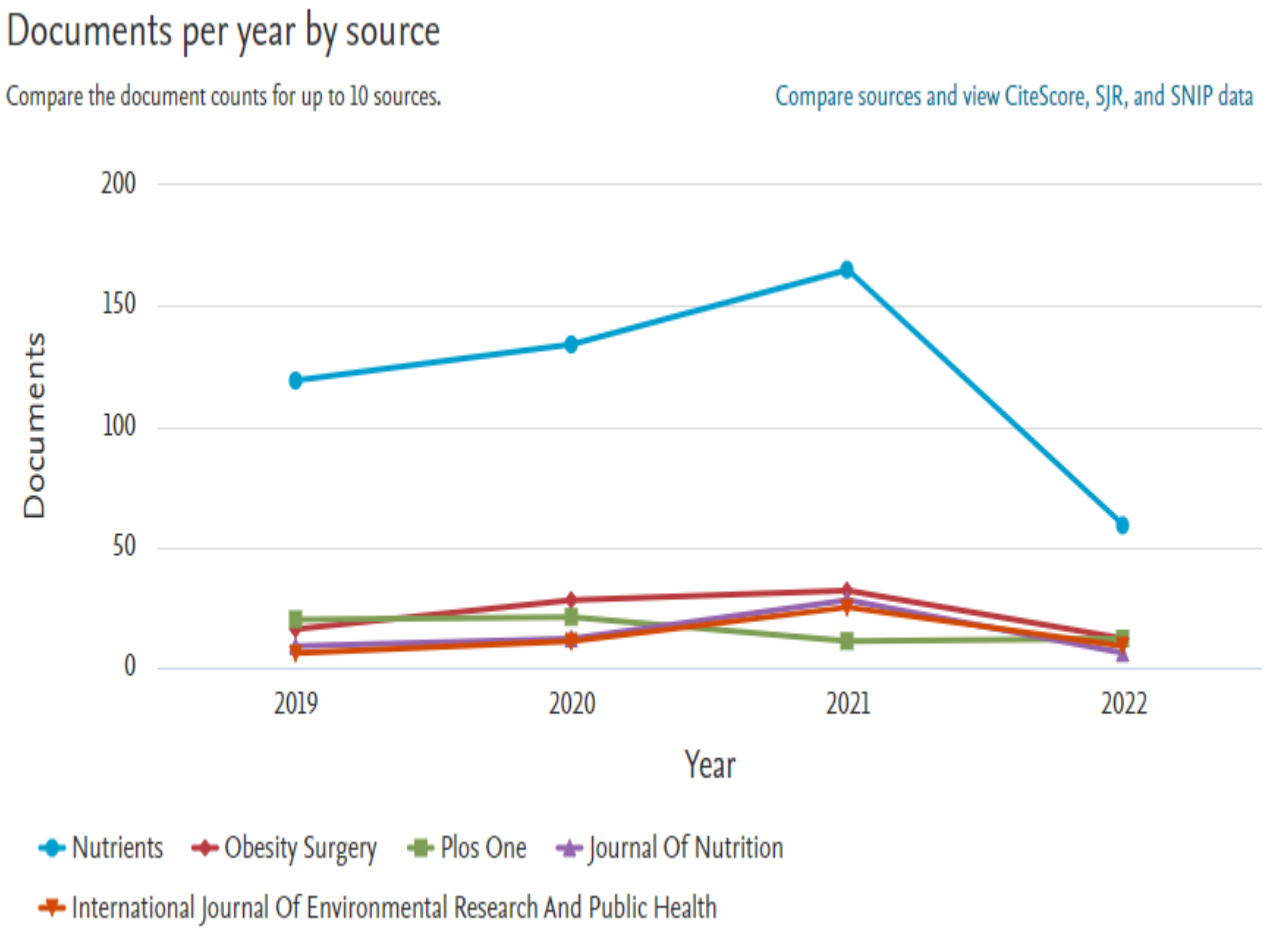
b) Document by subject area

Subject areas with the most number of documents on iron and vitamins



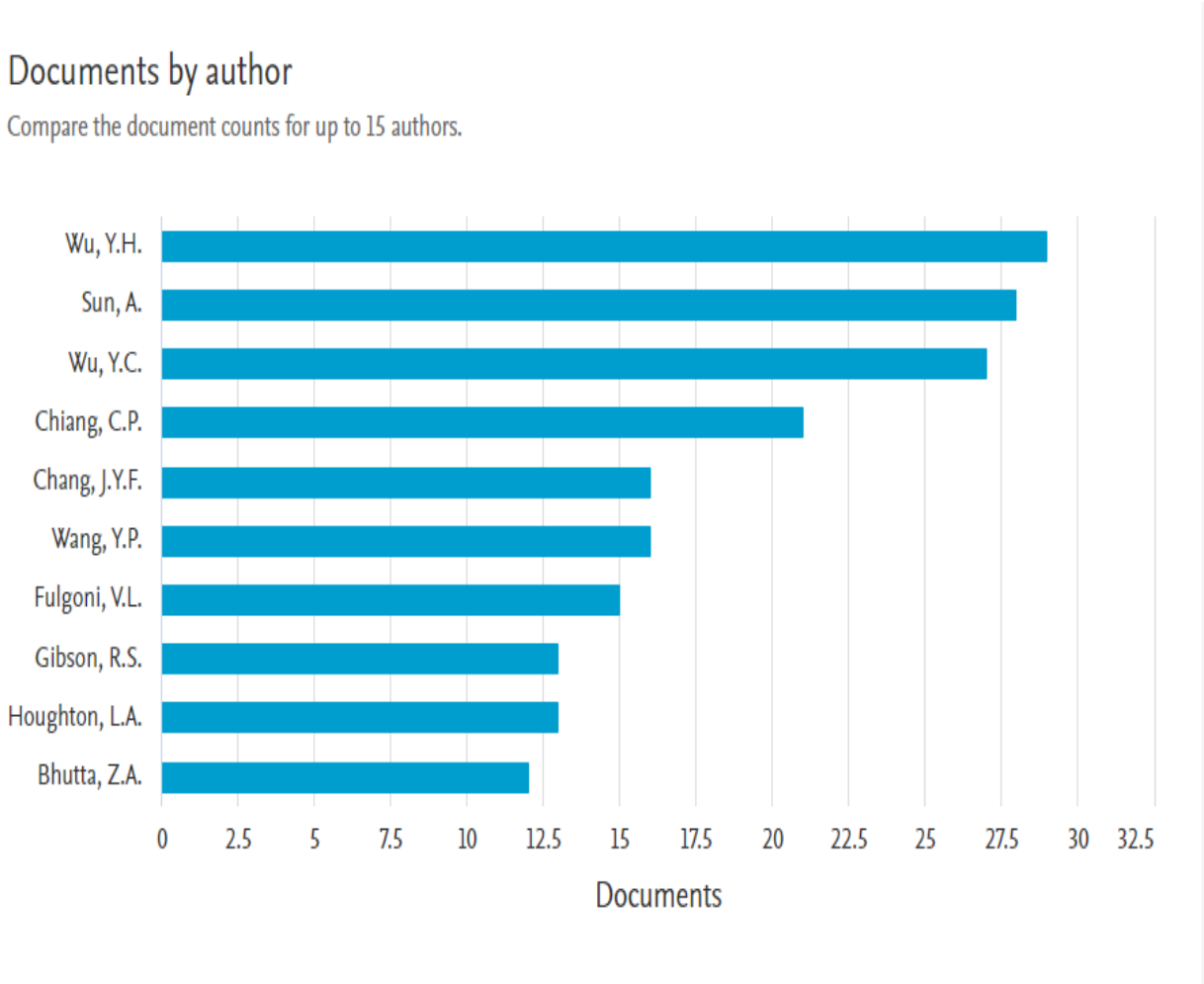
c) Documents by journals:

Journals that have published the most number of articles on iron and vitamins



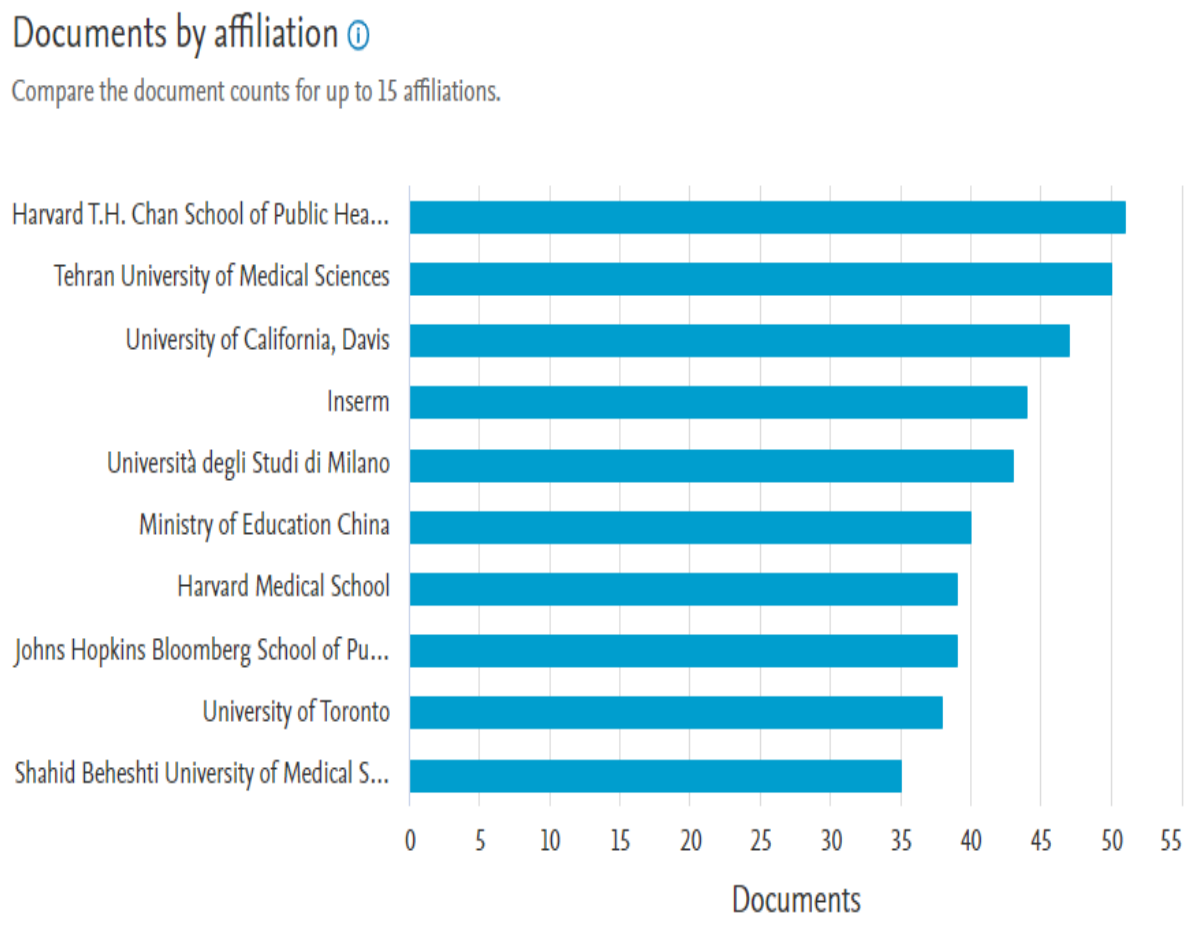
d) Documents by author:

Authors who have published the most number articles on iron and vitamins



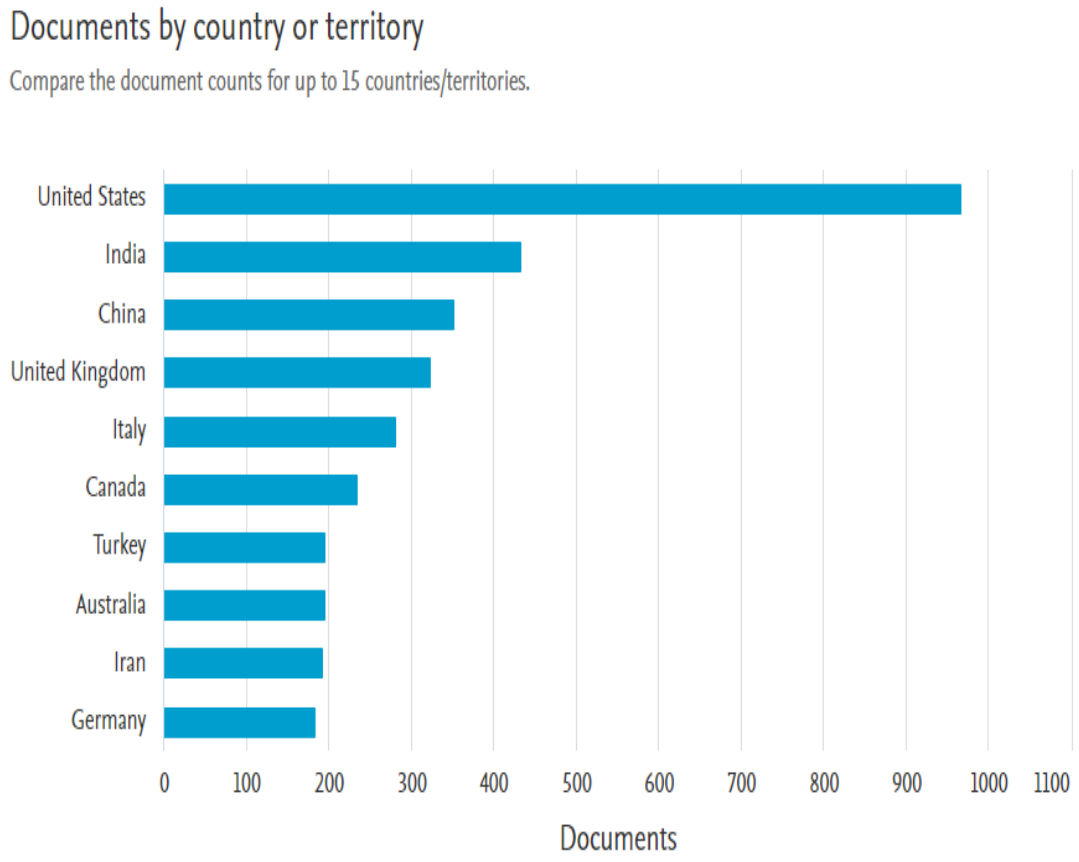
e) Documents by affiliation:

Affiliations that have published the most number of articles on iron and vitamins



f) Documents by country

Countries that have published the most number of articles on iron and vitamins



References

NHS. Overview. Vitamins and Minerals. https://www.nhs.uk/conditions/vitamins-and-minerals/ (accessed ?).

Web of Science https://0510m4wdw-y-https-www-webofscience-com.proxy.zendy.io/wos/diidw/summary/87907be1-564b-4e68-9558-40044b125fb1-48817aa5/diidw-relevance/1

Scopus https://0510a4wdv-y-https-www-scopus-com.proxy.zendy.io/term/analyzer.uri?sid=ae684731851e1b83f3ab0969b8ce61e3&origin=resultslist&src=s&s=TITLE-ABS-KEY%28Iron+and+Vitamins%29&sort=plf-f&sdt=b&sot=b&sl=32&count=25334&analyzeResults=Analyze+results&txGid=bf3abd2303e502140f531ccf8ccebfdc