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Chickpea: A Promising Solution for 'Hidden Hunger'

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Abstracts
Hidden hunger, also known as malnutrition, is a serious development challenge that affects people who have limited resources. It is characterized by a lack of essential vitamins, proteins and minerals, such as iron, zinc, iodine, and vitamins. Hidden hunger can have long-term, irreversible health effects and can also impact the economy. Using fortified foods has been one of the top strategies for lowering the 'hidden hunger' particularly for vulnerable households with limited dietary diversity. Protein supplements are commercially available for managing protein malnutrition. However, these remain inaccessible to the poor due to their high costs. Chickpeas has been reported to contain numerous vital nutrients, such as proteins, carbs, vitamins, minerals, fiber, and fatty acids that promote health. This study a reviewed chickpeas as a possible solution to protein and micronutrients malnutrition. Chick contains all the essential amino acids that that are necessary for protein synthesis yet cannot be synthesized by the human body. Histidine composition range was 0.55-3.66 g/100 g, isoleucine 0.71-9.78 g/100 g, leucine 0.57-10.60 g/100 g, lysine 0.72-7.30 g/100 g, methionine 0.13-2.42 g/100 g, phenylalanine 0.43-6.26 g/100 g, threonine 0.53-6.60 g/100 g, tryptophan 0.21-1.38 g/100 g and valine 0.74-7.29 g/100 g. Chickpeas was also found to be rich in nutrients such as include Mg, P, K, Na, Ca, Mn, Fe, Cu and Zn. Sulfur containing amino acids are present in limited amounts hence the recommendation that chickpeas diets be complemented with other plant based methionine rich foods especially for vegans.

Keywords*: Chickpeas; Hidden hunger; protein; amino acids; malnutrition*

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I. Introduction

Protein and micronutrient malnutrition in children is frequent in poor Asian and African countries, and it can have a negative impact on their health because of a lack of energy and protein in their diet [1]. Protein and micronutrient deficiency can have a variety of serious consequences for the body, including physical impacts, growth and development concerns, metabolic effects, and cognitive implications. Prolonged protein deficiency can result in chronic ailments such as heart disease and osteoporosis [2]. Addressing protein deficiency is critical for general health, especially in vulnerable populations such as children, the elderly, and people with chronic illnesses. A well-balanced diet rich in protein and micronutrient is critical for maintaining good health and avoiding these negative consequences.

Increasing availability and consumption of foods rich in micronutrients and proteins, particularly fortified foods, has been recommended as one of the top strategies for lowering the 'hidden hunger' of micronutrient malnutrition, particularly for vulnerable households with limited dietary diversity [3]. Protein supplements are commercially available in a variety of formats to meet varied dietary choices and demands (Table 1). These protein supplements are widely used for muscle rehabilitation, weight management, and general nutritional support [4]. However, the commercial protein supplements remain inaccessible to the poor due to their high costs. There is a need for alternative affordable and readily available protein foods.

Table 1: A list of common protein supplements along with a brief description of each

Serial no.	Protein	Description
1.	Whey protein	A fast-digesting protein derived from milk. It is rich in essential amino acids and is popular for muscle recovery and growth.
2.	Casein protein	A slow-digesting milk protein that provides a steady release of amino acids. It is often taken before bed to support overnight muscle recovery.
3.	Soy protein	A plant-based protein that contains all essential amino acids. It is a good alternative for vegetarians and vegans.
4.	Pea protein	A plant-based protein made from yellow split peas. It is hypoallergenic and suitable for those with dairy or gluten sensitivities.
5.	Hemp protein	Derived from hemp seeds, this protein contains omega-3 and omega-6 fatty acids, making it a nutritious plant-based option.
6.	Brown rice protein	A plant-based protein that is easily digestible and often combined with pea protein to create a complete amino acid profile.

7.	Egg white protein	Made from egg whites, this protein is rich in essential amino acids and low in fat and carbohydrates.
8.	Collagen protein	Sourced from animal connective tissues, collagen is beneficial for skin, joint health, and muscle recovery.
9.	Protein blends	These supplements combine different protein sources (e.g., whey, casein, and plant proteins) to provide a balanced amino acid profile.
10	Protein bars	Description: Convenient snacks that contain protein along with other nutrients. They come in various flavors and formulations.

Plants have long provided humanity with their basic necessities, including food, medicine and shelter [5-8]. Plants provide a genuine alternative to primary healthcare services in Sub-Saharan Africa's underdeveloped countries [9-16]. Previous research have shown that plant extracts have the capacity to manage diseases and pests. Plants produce crucial secondary metabolites that are harmful to infectious diseases [17-23]. In recent years, there has been an increase in the search for natural alternatives to synthetic chemicals used in the food, pharmaceutical, and cosmetic industries [24-29]. Plant extracts are recommended for disease control since they are safe for non-targeted organisms and the environment [30-35]. Furthermore, the risk that hazardous microorganisms may develop resistance to herbal treatments is exceedingly low [36-48].

Protein malnutrition, which is common among newborns and children in many developing countries, can be addressed by eating enough protein-rich foods [49]. Lentils, beans, and chickpeas are high in minerals, vitamins, and fiber, making them a vital part of a balanced diet for all populations. Dietary Guidelines for Indians [50] suggested that including pulses in one's daily diet, along with cereals, will help to mitigate protein energy malnutrition because cereals are deficient in lysine and pulses are deficient in sulfur-containing amino acids, and thus their combined diet provides all of the essential amino acids by complementing one another [51-53]. In recent years, more individuals have chosen plant-based diets, substituting vegetable protein for animal protein. This has increased demand for legumes, as they are the main source of plant protein [54]. One of the best ideas for ending the protein-calorie malnutrition that occurs in under developed nations is to increase the consumption of legumes since they are less expensive than animal protein [55-56].

Currently grown in over 65 countries, chickpea (*Cicer arietinum L.*) are the second most significant food legume crop worldwide [57]. About 20-25% of the world's total pulse production comes from this crop, which is grown on 17.81 million hectares and produces 17.19 million tons [58]. Chickpeas, which are naturally gluten-free, can greatly help to ease the issues of protein deficiency as it is grown all over the world. Chickpeas are also known as garbanzo beans, and are a common ingredient in Middle Eastern and Indian dishes like hummus, falafel, and chana masala. The legume is high in protein, fiber, folate, iron, and phosphorus, and can be eaten raw, boiled, or ground into flour (Figure 1). Chickpea is cool season crop and drought resistant [59-60]. Desi and Kabuli (Figure 2) are two type chickpea seeds that are distinguished by their size and color. Kabuli chickpeas are larger and have beige seed coat while Desi chickpeas are dark brown seed coat and have dark color seed coat [61].

Figure 1: Chickpeas plant, seeds and meal [60, 62]

Figure 2: Chickpeas types: Kabuli and Desi [63]

II. Chickpea Nutrients

Numerous vital nutrients, such as proteins, carbs, vitamins, minerals, fiber, and fatty acids that promote health, are abundant in chickpeas. Chickpeas have a protein content of 11–29%, dietary fiber content of 3.5-17.21%, fat level of 4-7%, and starch content of 50–60% [64-65]. According to Wallace et al., those who eat chickpeas consume higher levels of dietary fiber, polyunsaturated fatty acids, vitamin C, vitamin A, vitamin E, magnesium, potassium, and iron than people who don't eat it [66]. Chickpeas are mainly eaten in Western nations as "hummus." Four tablespoons of chickpea-based hummus per day is equivalent to two cups of legumes per week and provides about 25 g of dietary fiber [66]. A third cup of chickpeas has around 5.4 g of protein, 1.6 g of fat, 16.7 g of carbs, 4.6 g of dietary fiber, 29.9 mg of calcium, 1.8 mg of iron, 29.3 mg of magnesium, 177.4 mg of potassium, 104.9 µg of folate, 0.6 mg of vitamin A, and 0.2 mg of protein [67]. As a result, frequent chickpea eating can fulfill the daily amount of micronutrients and secondary macronutrients that are advised [68-69].

The γ-aminobutyric acid (GABA), one of the beneficial substances found in chickpeas, has been shown to reduce blood pressure, alleviate chronic diseases associated with alcohol, halt the growth of cancer cells, and regulate cholesterol levels. Chickpea is beneficial for many major human health issues, including cancer, heart disease, diabetes, hyperlipidemia, kwashiorkor, anemia, and digestive disorders [69-70]. Chickpea is the pulse with the highest protein and dietary fiber content (Table 2). High fiber diet is highly recommended for obese people, since fiber plays a significant role in weight loss. Dietary fiber can also help lower the risk of coronary heart disease, stroke, type 2 diabetes, gastrointestinal disorders, and high blood pressure [71]. Organic substances that lower the risk of diabetes mellitus, inflammation, hypertension, and metabolic syndrome include polyphenols and isoflavones, which are abundant in chickpeas [72]. Previous studies reported the antihypertensive effect of bioactive compounds from chickpea [73]. Because of its high protein bioavailability, balanced amino acid content, and comparatively low anti-nutritional components, chickpea protein is thought to be of higher quality than that of many other pulses [70].

Table 2: Protein and dietary fiber content of some chickpeas varieties

Type/ Cultivas	Crude fiber	Protein content (%)	Origin	Ref.
Chickpeas (D)	ND	20-25	Tunisia	74
El Patrón (D)	17.21	14.08	Mexico	65
5 Cultivars (D)	3.5-5.8	18-23	India	75
2 Cultivars (D)	ND	19.82-22.50	China	76
Chickpeas (D)	ND	20.29	Tunisia	77
Chickpeas (K)	ND	24.51	Tunisia	77
15 Genotypes (K)	ND	18.46 -24.46	Argentina	78
Chickpeas (K)	3.82-5.21	23.64-25.53	Egypt	79
Costa 2004 (K)	10.95	11.45	Mexico	65
20 Genotypes (K)	ND	20.97-30.13	Pakistan	80
4 Cultivars (K)	3.4-4.1	28-31	India	75
2 Cultivars(K)	ND	19.79-23.38	China	76
20 Cultivars*	ND-	22.12-24.42	Iran	81
GPF2*	ND	19.76	India	82

*Type of chickpea is not specified; D = Desi; K = Kabuli; ND = note determined

III. Impact of Food Processing on Chickpea Nutrients

To improve their digestibility, nutritional content, and palatability, chickpeas go through a number of pretreatments. These procedures include thermal (boiling, roasting and extrusion), biochemical (germination and fermentation), and physical (milling and soaking). These processes help to remove the anti-nutritional elements, shorten processing times, and also improve the nutritional value and attractiveness of chickpeas [83].

The chemical content is significantly influenced by the processing procedure [84, 76]. In a study by El-Adawy, cooking processes significantly decreased the non-protein nitrogen but increased the crude fiber of chickpeas[79]. Chickpea seed germination resulted in a considerable increase in crude protein, non-protein nitrogen, and crude fiber while microwave heating produced the highest retention of all minerals, followed by boiling and autoclaving [79]. In another study, it was found that roasting decreased the protein content of Arerti type chickpeas but increased the protein content of the Natoli variety [84]. According to a study by Kaur and Prasad, the Kabuli type of chickpeas showed increases in protein digestibility by 12.81%, crude oil content by 18.81%, and protein content by 1.59% following an 8-hour soaking period at 35°C [61]. This treatment also decreased anti-nutritional elements like phytate and tannin by 22.72% and 21.68%, respectively. Additionally, the chickpea's ash and carbohydrate levels decreased by 10.29 and 1.49%, respectively [83]. When chickpeas are fermented using *Cordyceps militaris* SN-18 for four days at 25°C, the protein content increases significantly by 19.43%. Additionally, the protein's emulsifying ability and stability improve by 73.79% and 12.30%, respectively [76].

IV. Importance of Amino acids and Proteins

The twenty standard amino acids are the building blocks of proteins and play essential roles in various biological processes. Each amino acid has unique properties that contribute to the structure and function of proteins in the body. These amino acids are categorized into essential, non-essential and conditional amino acids (Table 3 and Table 4). Essential amino acids are crucial for various bodily functions, including protein synthesis, hormone production, immune function, and neurotransmitter regulation [85]. They must be obtained through diet as the body cannot synthesize them. The nine essential amino acids are: histidine, isoleucine,

leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. Non-essential amino acids are synthesized by the body and are involved in various functions such as protein synthesis, neurotransmitter production, and metabolic processes. Nonessential means that our bodies can produce the amino acids, even if we do not get it from the food we eat. They are crucial for overall health and well-being [86]. Conditional amino acids are non-essential amino acids that become essential during times of illness, stress, or injury such as arginine, cysteine, glutamine, glycine, proline, serine, and tyrosine [87].

Table 3: Essential amino acids and their functions

Amino acid	Function
Histidine (His)	Important for the production of histamine, which is involved in immune responses, digestion, and sleep regulation.
Isoleucine (Ile)	Plays a role in muscle metabolism and is involved in energy production. It helps in hemoglobin formation and immune function.
Leucine (Leu)	Critical for protein synthesis and muscle repair. It also helps regulate blood sugar levels and stimulates the release of growth hormones.
Lysine (Lys)	Essential for protein synthesis, hormone production, and the absorption of calcium. It also plays a role in collagen formation.
Methionine (Met)	Acts as an antioxidant and is important for metabolism and detoxification. It also helps in the absorption of zinc and selenium.
Phenylalanine (Phe)	Precursor for neurotransmitters like dopamine, norepinephrine, and epinephrine. It plays a role in mood regulation.
Threonine (Thr)	Vital for protein synthesis, immune function, and the production of collagen and elastin.
Tryptophan (Try)	Precursor for serotonin, which regulates mood, sleep, and appetite. It also aids in the production of niacin (vitamin B_3).
Valine (Val)	Important for muscle metabolism, tissue repair, and energy production. It also helps maintain nitrogen balance in the body.

Table 4: Non-essential amino acids and their functions

Amino acid	Function
Alanine (Ala)	Plays a role in energy production and glucose metabolism. It helps in the conversion of pyruvate to glucose.
Arginine (Arg)	Arginine is a versatile amino acid that supports cardiovascular health, immune function, hormone regulation, and overall metabolic processes. It is particularly important for athletes and individuals recovering from injury.
Asparagine (Asn)	Involved in the synthesis of proteins and the metabolism of ammonia. It also plays a role in the nervous system.
Aspartic acid (Asp)	Important for the synthesis of other amino acids and neurotransmitters. It plays a role in the urea cycle and energy production.
Cysteine (Cys)	Acts as an antioxidant and is involved in the synthesis of proteins and metabolism of sulfur. It also helps in detoxification processes.
Glutamic acid (Glu)	Functions as a neurotransmitter and is involved in cognitive functions, learning, and memory. It also plays a role in metabolism.
Glutamine (Gln)	Important for immune function and gut health. It serves as a fuel source for cells in the intestines and is involved in nitrogen transport.
Glycine (Gly)	Plays a role in the synthesis of proteins, collagen, and neurotransmitters. It also has a calming effect on the brain.
Proline (Pro)	Essential for collagen production and tissue repair. It also plays a role in the metabolism of proteins and amino acids.
Serine (Ser)	Involved in the synthesis of proteins, neurotransmitters, and other amino acids. It plays a role in metabolism and immune function.
Tyrosine (Tyr)	Precursor for neurotransmitters such as dopamine, norepinephrine, and epinephrine. It is important for mental alertness and mood regulation.

V. Chickpeas Amino Acids

Different cultivar of chickpeas from different parts of the world have been studied to identify and quantify amino acid contents (Table 5). Out of the twenty standard amino acids required for protein biosynthesis, 18 were present in the samples at varied concentrations. All the essential amino acids were present in the chickpeas samples at varied concentrations. Histidine composition range was 0.55-3.66 g/100 g, isoleucine 0.71-9.78 g/100 g, leucine 0.57-10.60 g/100 g, lysine 0.72-7.30 g/100 g, methionine 0.13-2.42 g/100 g, phenylalanine 0.43-6.26 g/100 g, threonine 0.53-6.60 g/100 g, tryptophan 0.21-1.38 g/100 g and valine 0.74-7.29 g/100 g. For the non-essential amino acids, nine out of eleven amino acids were present in the studied chickpeas in the following ranges: alanine 0.88-4.67 g/100 g, arginine 1.89-9.3 g/100 g, aspartic acid 1.83-13.0 g/100 g, cysteine 0.14-1.82 g/100 g, glutamic acid 3.38-16.71 g/100 g, glycine 0.87-3.95 g/100 g, proline 0.01-4.5 g/100 g, serine 0.98-7.33 g/100 g and tyrosine 0.51-6.93 g/100 g. The two non-essential amino acids, asparagine and glutamine are missing from the chickpeas literature accessed by this study.

The human body needs macro-minerals and micro-minerals to function properly. These minerals are used in many physiological processes, including building blood and bone, regulating heartbeat, and making hormones [88]. Chickpeas have been subjected to qualitative and quantitative analysis to determine their elemental composition (Table 6). Macro and microelements present in chickpeas have been reported to include Mg, P, K, Na, Ca, Mn, Fe, Cu and Zn. Concentration of magnesium range was 4.3-224.8 g/100 g, phosphorous 168-553 g/100 g, potassium 291-1272 g/100 g, sodium 2.40-121 g/100 g, calcium 49-260.95 g/100 g, manganese 1.2-21.1 g/100 g, Iron 2.4-51.11 g/100 g, copper 0.13-12.2 g/100 g and zinc 1.53-68 g/100 g.

VI. Conclusion

This study confirms that chickpeas is rich in both essential and non-essential amino acids that are needed for biosynthesis of protein. It also contains high concentrations of macro and micro-nutrients that promote good health. The differences in the chemical composition found in the different seed types/ cultivars is attributed to variations in a growth environment, varietal characteristics, climate, soil nutrient content agronomic practices, genotypic diversity, storage conditions or variation in processing methods [84,76]. This study further confirms that chickpea is rich in lysine but low in the sulfur containing amino acids as was reported by previous studies [98, 91]. This limitation can be avoided by complementing the chickpeas meals with protein sources with higher levels of methionine to improved amino-acid profile. Methionine rich plant foods include spirulina, hemp seeds, squash and pumpkin seeds, chia seeds, sunflower seeds, flax seeds and cashew nuts.

Table 5: Amino acid composition of some chickpea cultivars

Amino acid	Desi	Kabuli	GPF2*	Chickpea*	Chickpea*	Twenty cultivars*	Kabuli	Desi	Six cultivars (D &K)	Five cultivars*	Six cultivars (D &K)	Chickpea*	Range
Essential amino acids (g/100 g)													
His	3.27	2.70	ND	2.51	0.61	1.86-3.66	0.77-0.79	0.65-0.73	2.89	2.3-2.8	0.55–0.66	0.63	0.55-3.66
Ile	ND	ND	ND	4.34	0.71	7.48-9.78	0.97- 0.98	0.92-0.93	4.22	3.1-4.0	0.86–0.99	0.99	0.71-9.78
Leu	4.24	2.48	ND	7.40	1.31	7.34- 10.60	1.65-1.7	1.45-1.55	7.64	6.4-7.1	0.57–1.81	1.77	0.57-10.60
Lys	7.25	7.63	5.45	6 59	1.42	2.36- 2.80	1.60-1.75	1.40	7.30	6.2-6.7	0.72-1.71	1.63	0.72-7.30
Met	1.41	1.14	2.42	1.16	0.23	0.15- 1.16	0.27-0.37	0.23	Met + Cys (2.63)	1.3-1.7	0.13–0.16	0.16	0.13-2.42
Phe	5.84	4.53	ND	6.26	1.23	0.43-4.95	1.45-1.50	1.20 -1.30	Try + Phe (6.56)	5.1-5.8	1.25–1.45	1.41	0.43-6.26
Thr	4.02	4.02	ND	3.55	0.87	1.76-6.60	0.80-0.82	0.63-0.65	3.63	3.1-3.4	0.53–0.72	0.89	0.53-6.60
Try	ND	ND	1.22	0.95	ND	0.63- 1.38	ND	ND	1.41	ND	ND	0.21	0.21-1.38
Val	4.69	3.20	ND	4.69	0.74	5.18- 7.29	1.05 1.10	0.99-1.10	3.80	3.5-4.1	0.88–1.04	1.04	0.74-7.29
Non- essential amino acids (g/100 g)													
Ala	4.11	3.52	ND	4.67	0.88	ND	0.98-1.00	0.86-0.90	ND	3.7-4.8	0.95–1.14	1.01	0.88-4.67
Arg	8.90	8.84	ND	8.59	1.89	ND	2.40-2.65	2.10-2.40	ND	7.8-9.3	2.22–2.60	2.39	1.89-9.3
Asp	10.73	11.30	ND	11.7	1.83	ND	2.80	2.45	ND	11.4-13.0	2–2.95	ND	1.83-13.0
Cys	ND	ND	1.82	1,27	0.34	ND	ND	ND	ND	ND	0.14–0.16	0.23	0.14-1.82
Glu	14.90	16.71	ND	14.9	3.38	ND	4.35-4.50	3.85	ND	14.2-16.7	3.7–4.53	ND	3.38-16.71
Gly	3.90	3.90	ND	3.95	0.76	ND	0.95 0.98	0.84-0.93	ND	3.5-3.9	0.87–1.04	0.91	0.87-3.95
Pro	3.63	2.95	ND	3.74	0.69	ND	1.60-1.95	1.00-1.10	ND	3.6-4.5	1.04–1.36	0.01	0.01-4.5
Ser	5.40	7.33	ND	5.1	1.23	ND	1.15-1.25	0.98	ND	4.6-5.2	1.08–1.29	1.32	0.98-7.33
Tyr	2.87	6.93	ND	2.88	0.58	ND	0.73-0.81	0.57-0.61	ND	2.4-2.9	0.51–0.60	0.65	0.51-6.93
Source	Tunisian	Tunisia	India	India	Italy	Iran	China	China	India	Turkey	China	Spain	
Ref.	77	77	82	89	90	81	76	76	58	91	72	92	

* Type of chickpea is not specified; D = Desi; K = Kabuli; ND = note determined

Table 6: Mineral composition (g/100 g) of some chickpea cultivars

Type	Mg	P	K	Na	Ca	Mn	Fe	Cu	Zn	Origin	Ref.
Desi	133.6	ND	ND	7.35	177.94	3.71	48.26	0.58	3.32	Tunisia	77
Kabuli	115.5	ND	ND	11.26	187.25	3.88	51.11	0.7	4.18	Tunisia	77
Kabuli	145-170	457-553	352-1172	ND	132-191	2.1-4.1	4.6-6.7	0.96-1.39	3.11-5.22	Argentina	78
Chickpeas*	165-176	195-239	341-870	114-121	124-176	1.80-2.11	6.81-7.91	0.73-1.10	3.42-4.93	Egypt	79
Desi	169·1	377·3	1215·7	ND	161·7	3·4	5·9	1·0	3·6	China	93
Kabuli	177·8	505·1	1127·2	ND	106·6	3·9	5·5	1·0	4·4	China	93
Chickpeas*	164	ND	748	2.40	200	0.45	4.30	0.83	4.20	Italy	90

Chickpeas*	176	226	870	121	176	21.1	7.72	1.10	43.2	Egypt	79
Chickpeas*	46	251	1155	101	197	1.9	3.0	11.6	68	Pakistan	94
Chickpeas* (Dry)	79	252	718	24	57	21.3	4.31	0.65	2.76	US	66
Chickpeas* (Cooked)	48	168	291	7	49	1.03	2.89	0.35	1.53	US	66
Chickpeas*	71.96–180.06	ND	ND	ND	53.7–260.95	1.31–4.07	5.80–9.87	0.13–0.47	1.63–4.05	Italy	73
Chickpeas*	176	226	870	121	176	2.11	7.72	1.10	4.32	Egypt	95
Chickpeas*	106.71–123.90	ND	ND	ND	164.31-211.67	ND	5.86–6.68	ND	2.17–2.57	France	96
Chickpeas*	197.7-224.8	ND	ND	ND	ND	ND	5.49-7.36	ND	3.61-4.80	China	76
Chickpeas*	214.8-230.5	ND	ND	ND	ND	ND	6.19-9.72	ND	4.47-5.33	China	76
Chickpeas*	4.3-5.0	239-263	1109-1272	96-107	185-219	1.2-2.3	2.4-4.1	10.7-12.2	3.5-6.0	Pakistan	97
Range	4.3-224.8	168-553	291-1272	2.40-121	49-260.95	1.2-21.1	2.4-51.11	0.13-12.2	1.53-68		

* The type of chickpea is not specified; D = Desi; K = Kabuli; ND = note determined

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