IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Prevention And Management Of Kwashiorkor (Edematous Malnutrition)-A Review Article

*Dr. Tanveer Ahmad khan [1], Dr. Saquib Hussain [2], Dr. Nargis Bano, [3]

Dr. Anisa Begum [4], Dr. Ahmad Raza[5],

[1] Professor & HOD, Dept. of Tahaffuzi wa samaji Tib, Ahmad Garib Unani Medical College, Akkalkuwa.

[2] Professor & HOD, Dept. of Moalijat, Ahmad Garib Unani Medical College, Akkalkuwa.

[3] Professor & HOD, Dept. of Manafe-ul-Aza Ahmad Garib Unani Medical College, Akkalkuwa.

[4] Professor & HOD, Dept. of Jarahiyat, Ahmad Garib Unani Medical College, Akkalkuwa.

[5] Professor and HOD, Dept. of Ilaj Bit Tadbeer, Ahmad Garib Unani Medical College, Akkalkuwa

I. Malnutrition- Kwashiorkor and Marasmus

The distinction between the two extreme forms of protein-energy malnutrition, kwashiorkor and marasmus, has been accepted by clinicians for many years. The syndrome of kwashiorkor came to dominate the interests of tropical nutritionists when it was recognized after the Second World War as a major cause of death in young children. Children aged 1-3 years often presented after weaning with the acute onset of cedema and desquamating, dys pigmented skin. Many had thin, red and friable hair and they were apathetic and anorexic. Some cases, particularly in the West Indies, also had hepatomegaly with occasional jaundice. The children's weight was usually below normal, coexisting respiratory and intestinal infections were frequent and specific vitamin deficiencies, e.g. vitamin A deficiency with xerophthalmia, were also found and seemed to Increase the mortality rate even further (Waterlow et al. 1960). Dr. Cecily Williams (1933), working in the Gold Coast, had shown that the syndrome was cured by feeding the child on breast milk; this and the early demonstration of hypo albumin Tmia was in keeping with the concept of a protein deficiency disease. The prompt rise in serum albumin levels on feeding purified casein or amino acids seemed to confirm the specific nature of the protein deficient state (Brock et al. 1955). Marasmus was at this stage largely ignored. The Clinical signs were not as florid as those in kwashiorkor and much of the work on nutrition was conducted in the African and Caribbean colonies where kwashiorkor seemed to be more prevalent. In the last ten years, however, marasmus has emerged as a major problem of increasing severity as societies become more industrialized and populations move from rural areas to large urban slums where traditional infant rearing practices are disrupted. The marasmic child is often younger than a child with kwashior and very small for his age; when compared with a normal child the marasmic infant has a marked deficit in both weight and height. Wasting of adipose tissue and muscle occurs to an extraordinary degree. Yet, despite these severe changes, hepatomnegaly and

cedema are absent, the skin usually appears normal, there are few hair changes and the child is alert and hungry. Although hypoalbuminxmia occurs in some cases the fall in serum albumin is much less than that seen in kwashiorkor. In view of this clinical picture it seemed not unreasonable, therefore, to think of the marasmic child as simply suffering from starvation. Initial attempts to treat marasmic children with diets rich in protein hadbeen disappointing until feeding studies with arrange of energy and protein intakes showed that much higher energy supplies were needed for the rapid recovery (Ashworth et al. 1968).The distinction between the two disorders soon proved to be of limited practical use since many children in South Africa, Asia, Central and South America and the Caribbean were presenting with some features of both kwashiorkor and marasmus. This led to the use of the all-embracing term (protein-calorie malnutrition' (Jelliffe 1959) to include the whole spectrum of disorders. Cases of the intermediate forms of malnutrition,
characterized by both cedema and wasting, were classified as 'marasmus-kwashiorkor'.

The concept of Kwashiorkor as a simple protein deficiency state arising from the plentiful consumption of a carbohydrate-rich, low protein diet also seemed too simple since in some countries, such as India, children developed either kwashiorkor or marasmus on a cereal-based diet, which was qualitativelyno different from that of other children in the community (Gopalan 1968). Autret & Behar (1954) had also shown that children with kwashiorkor were often consuming a diet poor in energy as well as in protein, and this was later to be confirmed by Rutishauser & Whitehead (1972) in their Ugandan studies on children from a community with a high incidence of kwashiorkor.

Fig. 1 Kwashiorkor in African countries

Fig. 2 Child suffering in Kwashiorkor

Kwashiorkor was present in the world long before 1933, when Cecily Williams published research which took the Ga name for the disease. There were already many names for the illness which referenced the cessation of breastfeeding, or the consumption of monotonous diets high in starch. However, Williams was the first to suggest that this might be a deficiency of protein or an amino acid. Despite publishing in 1933, it was only in 1949 that the World Health Organization officially recognized kwashiorkor as a public health concern. This period also correlated with the promotion of infant formula, often by European colonial powers.

The substitution of formula for breast milk contributed significantly to the increasing visibility of kwashiorkor throughout the twentieth century.

II. Epidemiology of Kwashiorkor.

Kwashiorkor is rare in high income countries. It is mostly observed in low-income and middle income nations and regions such as Southeast Asia, Central America, Congo, Ethiopia, Puerto Rico, Jamaica, South Africa, and Uganda, where poverty is prominent. Occurrences of severe malnutrition also tend to trend higher under conditions of food insecurity, higher prevalence of infectious diseases, lack of access to appropriate care, and poor living situations with inadequate sanitation.

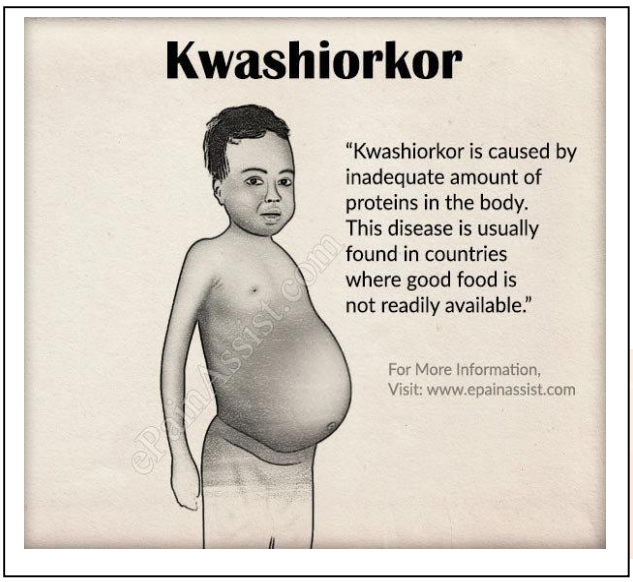

Fig. 3 Kwashiorkor-Nutrition Disease

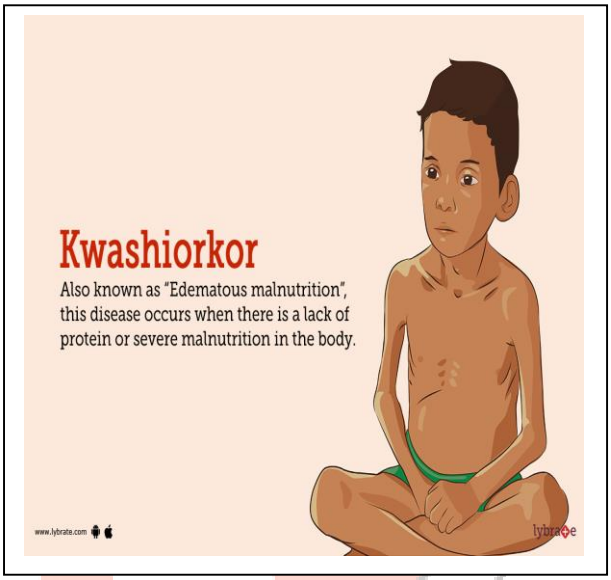

Fig. 4 Kwashiorkor-A Poverty disease

Communities experiencing famine are affected the most especially during the rainy season. Prevalence varies, but it affects children of either sex commonly under five years old. "Globally, kwashiorkor in-directed accounted for 53% of deaths among children under five between 2000 and 2003 when associated with other common childhood diseases like acute respiratory infections, malaria, measles, HIV/AIDS and other causes of perinatal deaths." When compared to marasmus in developing countries, kwashiorkor typically has a lower prevalence, "0.2%-1.6% for kwashiorkor and 1.2%-6.8% for marasmus." Factors such as "diet, geographical locations, and climate and aflatoxin exposure" have been invoked as potential causes for observed differences in the prevalence for kwashiorkor and marasmus. In general, in areas where Severe Acute Malnutrition (SAM) is prevalent, marasmus is more often the dominant SAM condition. However, in certain areas kwashiorkor may be more common than marasmus.

III. Definition of kwashiorkor

Kwashiorkor, also known as "edematous malnutrition" because of its association with edema (fluid retention), is a nutritional disorder most often seen in regions experiencing famine. It is a form of malnutrition caused by a lack of protein in the diet. People who have kwashiorkor typically have an extremely emaciated appearance in all body parts except their ankles, feet, and belly, which swell with fluid. Kwashiorkor is rarely found in the United States and other countries with a generally steady food supply. It's most common in sub-Saharan Africa and other countries where people routinely have a limited supply of food. Most people who are affected by kwashiorkor recover fully if they are treated early. Treatment involves introducing extra calories and protein into the diet. Children who develop kwashiorkor may not grow or develop properly and may remain stunted for the rest of their lives. There can be serious complications when treatment is delayed, including coma, shock, and permanent mental and physical disabilities. Kwashiorkor can be life-threatening if it's left untreated. It can cause major organ failure and eventually death.

IV. Causes of kwashiorkor.

Kwashiorkor is caused by a lack of protein in the diet. Every cell in your body contains protein. You need protein in your diet for your body to repair cells and make new cells. A healthy human body regenerates cells in this way constantly. Protein is also especially important for growth during childhood and pregnancy. If the body lacks protein, growth and normal body functions will begin to shut down, and kwashiorkor may develop. Kwashiorkor is most common in countries where there is a limited supply or lack of food. It is mostly found in children and infants in sub-Saharan Africa, Southeast Asia, and Central America. A limited supply or lack of food is common in these countries during times of famine caused by natural disasters such as droughts or flood or political unrest. A lack of nutritional knowledge and regional dependence on low-protein diets, such the maize-based diets of many South American countries, can also cause people to develop this condition. This condition is rare in countries where most people have access to enough food and are able to eat adequate amounts of protein. If kwashiorkor does occur in the United States, it can be a sign of abuse, neglect, or fad diets, and it's found mostly in children or older adults. It can also be a sign of an underlying condition, such as HIV.

V. Symptoms of kwashiorkor.

The symptoms of kwashiorkor include:

- Change in skin and hair color (to a rust color) and texture
- Fatigue
- Diarrhea
- Loss of muscle mass
- Failure to grow or gain weight
- Edema (swelling) of the ankles, feet, and belly
- Damaged immune system, which can lead to more frequent and severe infections
- Irritability
- Flaky rash

- Shock

VI. Diagnosis of kwashiorkor

If kwashiorkor is suspected, your doctor will first examine you to check for an enlarged liver (hepatomegaly) and swelling. Next, blood and urine tests may be ordered to measure the level of protein and sugar in your blood. Other tests may be performed on your blood and urine to measure signs of malnutrition and lack of protein. These tests may look for muscle breakdown and assess kidney function, overall health, and growth. These tests include:

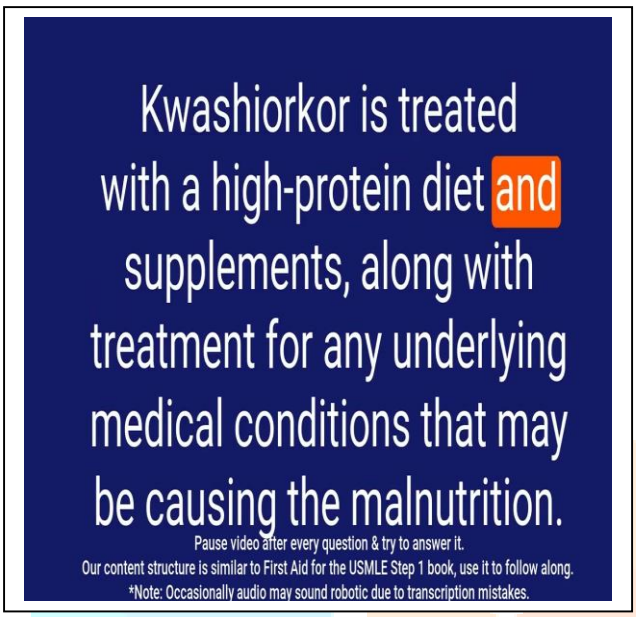

Fig. 5 Protein control to Kwashiorkor

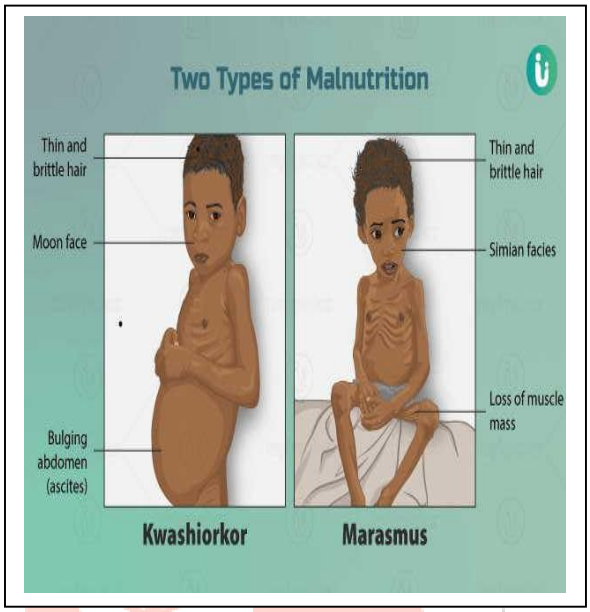

Fig. 6 Types of Malnutrition

- Arterial blood gas
- Blood urea nitrogen (bun)
- Blood levels of creatinine
- Blood levels of potassium
- Urinalysis
- Complete blood count (cbc)

VII. Effect of Kwashiorkor on the Physiology

Kwashiorkor is characterized by peripheral edema in a starving individual. The lack of fluid equilibrium between hydrostatic pressure and oncotic pressure across capillary blood vessel walls causes edema. The quantity of albumin increases the oncotic pressure, which allows the body to maintain fluids inside the vasculature. Kids with Kwashiorkor had incredibly low amounts of albumin, causing them to become intra-vascularly deficient, and hence, antidiuretic hormone (ADH) rises in reaction to hypovolemia, causing edema. Plasma renin reacts vigorously as well, increasing salt retention. These variables all lead to edema. Low glutathione (antioxidant) levels are also a feature of Kwashiorkor. It is assumed to be due to the impoverished child's elevated levels of oxidant stress. Increased oxidant amounts are frequent during fasting and have even been observed in situations of chronic inflammation. Better nutritional status and sulfur-containing antioxidants would've been one indicator of reversion.

VIII. Treatment of kwashiorkor.

Kwashiorkor can be corrected by eating more protein and more calories overall, especially if treatment is started early. You may first be given more calories in the form of carbohydrates, sugars, and fats. Once these calories provide energy, you will be given foods with proteins. Foods must be introduced and calories should be increased slowly because you have been without proper nutrition for a long period. Your body may need to adjust to the increased intake. Your doctor will also recommend long-term vitamin and mineral supplementation to your diet. The ten fundamental concepts listed below are widely employed to manage patients hospitalized for **Kwashiorkor**. These concepts are implemented in stages, beginning with emergency stabilization and progressing to final rehabilitation.

- Thirst treatment/prevention
- Begin eating with caution.
- Making preparations for a follow-up appointment following recuperation.
- **Hypothermia** Treatment and prevention
- Hypocalcemia treatment/prevention
- Offering sensory input as well as psychological support
- Infections treatment/prevention
- Micronutrient deficiency correction
- Obtaining catch-up growth
- Restoring electrolyte balance
- The entire course of therapy takes between 2 and 6 weeks.

Treatment for malnutrition depends on the cause and how bad the condition is. If you have malnutrition, you may get advice you can follow at home. You may need to see a dietitian or other qualified healthcare professional at home. In severe cases, you may need hospital treatment.

A. Dietary changes and supplements

A dietitian will tell you what dietary changes may help. They may create a tailored diet plan so you get enough nutrients. They may also suggest:

- Having a healthier, more balanced diet
- Eating 'fortified' foods that contain extra nutrients
- Snacking between meals
- Having drinks that contain lots of calories
- Getting home supermarket deliveries

If these aren’t enough, they may recommend you take supplements. Only take these if advised to by a healthcare professional.

B. Feeding tubes

You may not be able to eat what you need. For example, if you have a problem swallowing. If you do, you will need another way to get nutrients.

This may involve a:

- Tube that goes down the nose, into the stomach - called a nasogastric tube
- Tube that goes through the skin of the tummy, into the stomach or gut
- Nutrient solution that goes into the blood through a tube in a vein - called a parenteral nutrition

These treatments usually begin in hospital. But they can continue at home if the person is well enough.

C. Care and support services

Some people need extra care to help them cope with other issues such as limited mobility.

This may include:

- Home care visitors who can shop for food or cook for people
- An occupational therapist who can assess daily activities and find solutions
- A 'meals on wheels' or meals at home service
- A speech and language therapist who can teach exercises that help people swallow and give advice on foods that are easy to swallow

D. Treating malnutrition in children

Malnutrition in children is often caused by long-term health conditions. But this isn't the case for all children with malnutrition. Treatment may involve:

- Dietary changes, such as eating foods high in energy and nutrients
- Support for families to manage underlying factors affecting the child's nutritional intake
- Treatment for any underlying medical conditions causing their malnutrition
- Vitamin and mineral supplements
- High energy and protein supplements, if other treatments do not work on their own

Severely malnourished children need to be fed and rehydrated with great care. They cannot have a normal diet straight away and may need time in hospital. Once they're well enough, they can slowly return to a normal diet. Treatment should be tracked to make sure it's working. Weight and height will also be measured often. If there's no improvement, a malnourished child will be referred to specialist services.

IX. Complications of kwashiorkor

Even with treatment, children who have had kwashiorkor may never reach their full growth and height potential. If treatment comes too late, a child may have permanent physical and mental disabilities. If left untreated, the condition can lead to coma, shock, or death. Complications of undiagnosed or poorly managed **Kwashiorkor** can be significant, even fatal, in certain individuals, particularly babies and children. The danger can be reduced by adhering to the planned treatment plan.

Kwashiorkor complications include

- Malformations of the gastrointestinal system, such as pancreatic atrophy with consequent glucose intolerance, shrinkage of the small intestine mucosa, lactase deficiency, ileus, and bacterial translocation, which can lead to bacterial septicemia and mortality
- Electrolyte imbalances are prevalent & Hepatomegaly
- Hypothermia and metabolic abnormalities
- Cardiovascular collapse and hypovolemic shock
- In Endocrinopathies, insulin levels are low; growth hormone levels are high, but insulin-like growth factor levels are low. It results in insulin resistance.
- Infections of the urinary tract & Cellular dysfunction, including endothelial dysfunction

X. Herbal Drugs used to control Kwashiorkor

Proteins are a large category of molecules that support cell structure, immune function, movement, chemical reactions, hormone synthesis, and more. They're all made up of tiny building blocks called amino acids. Nine of these are essential–meaning your body needs them but can't make them on its own, so you need to get them in your diet. Not only is protein essential for your health but consuming it can keep you feeling full and satisfied, which supports a healthy body weight.

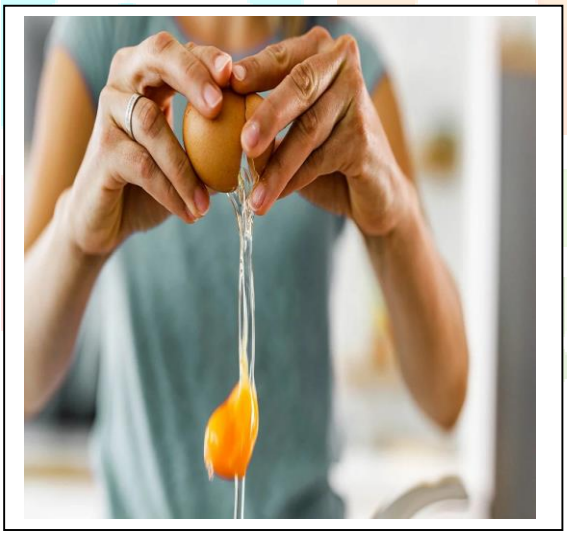

Fig. 7 Egg used in treatment of Kwashiorkor

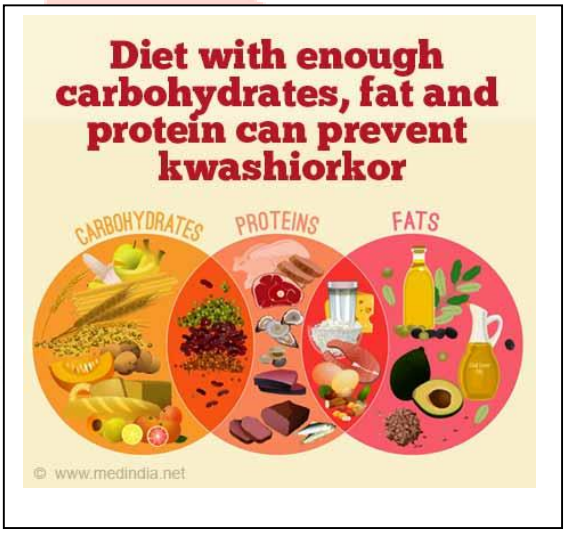

Fig. 8 Protein carbohydrate and Fat used in Kwashiorkor in African countries

A. Eggs

Whole eggs are a good source of protein that's easy to absorb, and they're also an excellent source of vitamins, minerals, healthy fats, and antioxidants. Remember that egg whites are almost pure protein, but whole eggs that include the yolk provide many more nutrients, including vitamins, minerals, antioxidants, and healthy fats.

B. Almonds

Almonds are a nutritious tree nut rich in essential nutrients like fiber, vitamin E, manganese, and magnesium. They're also high in plant-based protein. Eating almonds may benefit your health in several ways, including lowering heart disease risk factors like high LDL (bad) cholesterol and high blood pressure.

C. Chicken breast & cottage Cheese.

Chicken breast is an excellent choice if you're trying to bincrease your protein intake. In addition to protein, chicken provides a variety of B vitamins, plus minerals like zinc and selenium.

Cottage cheese is a type of cheese that is low in fat and calories yet high in protein. It's rich in calcium, phosphorus, selenium, vitamin B12, riboflavin (vitamin B2), and various other nutrients.

D. Greek yogurt & Milk.

Greek yogurt, also called strained yogurt, is a very thick type of yogurt high in protein. It has a creamy texture and is a good source of many nutrients like calcium, vitamin B12, vitamin A, selenium, and zinc .

Dairy milk contains a little of nearly every nutrient that your body needs. It's a good source of high quality protein, and it's high in vitamins and minerals, like calcium, phosphorus, and riboflavin (vitamin B2). Many people with lactose intolerance can't tolerate milk and other dairy products, and they avoid many dairy-containing foods.

E. Lentils

Lentils are among the richest sources of plant-based protein, making them an excellent choice if you follow a vegetarian or vegan diet. Plus, they're loaded with other nutrients, too, including fiber, folate, magnesium, potassium, iron, copper, and manganese. Studies show that people who regularly consume lentils and other legumes have a lower risk of developing health conditions like heart disease and fatty liver disease.

F. Lean beef

Lean beef is a rich source of protein. It's also high in bioavailable iron, zinc, selenium, and vitamins B12 and B6. Red meat can be a part of a healthy diet, but it's best to moderate your intake. Consuming high amounts of red meat has been linked to a higher risk of developing certain health conditions, including colorectal cancer. Try cutting back on red meat and eating plant-based protein, fish, and poultry more frequently.

G. Fish

Fish is an excellent source of protein and provides several important vitamins and minerals, like iodine, selenium, and vitamin B12 . People who include a lot of fish in their diet tend to have a lower risk of health conditions like heart disease and type 2 diabetes. Plus, fatty fish like salmon and herring are high in omega-3 fats, which have powerful benefits for your overall health, including supporting heart health.

H. Quinoa

Quinoa is rich in fiber, folate, copper, iron, and zinc, and it's higher in protein than many grains. Quinoa is often referred to as a complete protein because it contains all nine essential amino acids that your body can't make on its own. However, it actually contains insufficient amounts of certain amino acids, like leucine.

I. Protein powders

When you're pressed for time and unable to prepare a meal, protein powder can come in handy. You can easily add protein powders like whey and pea protein to shakes, smoothies, energy balls, yogurt, and more to increase the protein and fullness factor.

J. Ezekiel bread

Ezekiel bread is different from most other breads. It's made of organic and sprouted whole grains and legumes, including millet, barley, spelt, wheat, soybeans, and lentils. Compared with other breads, like white bread, Ezekiel bread is high in protein, fiber, and various important nutrients.

K. Pumpkin seeds

Pumpkin seeds are a great source of minerals like iron, phosphorus, magnesium, and zinc. Plus, they're loaded with plant-based protein and fiber. Try adding pumpkin seeds to salads, baked goods, oatmeal, or yogurt, or mix them with unsweetened dried fruit and almonds for a convenient snack.

L. Turkey breast

Turkey breast consists mostly of protein, with very little fat and few calories. It also contains several vitamins and minerals, including selenium, zinc, and vitamins B12 and B6.

J. Shellfish

Shellfish, including shrimp, oysters, clams, and scallops are excellent sources of protein. Plus, shellfish contain healthy fats and a number of vitamins and minerals, including selenium, zinc, vitamin B12, and iron.

K. Peanuts and peanut butter

Peanuts and peanut butter are packed with nutrients like protein, folate, magnesium, and vitamin E. Eating peanuts and peanut butter may help make you feel full due to their high protein content. In fact, studies show that adding peanut butter to a high carb meal may help reduce blood sugar spikes after the meal.

References:

1. Wells, John C. (2008). Longman Pronunciation Dictionary (3rd ed.). Longman. ISBN 978-1-4058-8118-0.
2. Benjamin, Onecia; Lappin, Sarah L. (2022). "Kwashiorkor". StatPearls. Stat Pearls Publishing. PMID 29939653. NBK507876.
3. Pham, Thi-Phuong-Thao; Alou, Maryam Tidjani; Golden, Michael H.; Million, Matthieu; Raoult, Didier (January 2021). "Difference between kwashiorkor and marasmus: Comparative meta-analysis of pathogenic characteristics and implications for treatment". Microbial Pathogenesis. **150**: 104702. doi:10.1016/j.micpath.2020.104702. PMID 33359074. S2CID 229694345.
4. Liu T, Howard RM, Mancini AJ, Weston WL, Paller AS, Drolet BA, et al. (2001). "Kwashiorkor in the United States: fad diets, perceived and true milk allergy, and nutritional ignorance". Archives of Dermatology. **137** (5): 630–6. PMID 11346341.

5. Nott, John (May 2021). "'No one may starve in the British Empire': Kwashiorkor, Protein and the Politics of Nutrition between Britain and Africa". Social History of Medicine. **34** (2): 553–576. doi:10.1093/shm/hkz107. PMC 8162845. PMID 34084092.

6. Williams CD (1983) [1933]. "Fifty years ago. Archives of Diseases in Childhood 1933. A nutritional disease of childhood associated with a maize diet". Archives of Disease in Childhood. **58** (7): 550–60. doi:10.1136/adc.58.7.550. PMC 1628206. PMID 6347092.

7. Williams CD, Oxon BM, Lond H (1935). "Kwashiorkor: a nutritional disease of children associated with a maize diet. 1935". Bulletin of the World Health Organization. **81** (12): 912–3. doi:10.1016/S0140-6736(00)94666-X. PMC 2572388. PMID 14997245. Reprint: Williams CD, Oxon BM, Lond H (2003). "Kwashiorkor: a nutritional disease of children associated with a maize diet. 1935". Bulletin of the World Health Organization. **81** (12): 912–3. doi:10.1016/S0140-6736(00)94666-X. PMC 2572388. PMID 14997245.

8. Stanton, J. (2001). "Listening to the Ga: Cicely Williams' Discovery of Kwashiorkor on the Gold Coast" (PDF). Women and Modern Medicine. Clio Medica. Vol. 61. pp. 149–171. doi:10.1163 /9789004333390 _008. ISBN 978-90-04-33339-0. PMID 11603151.

9. Bhutta, Zulfiqar A.; Berkley, James A.; Bandsma, Robert H. J.; Kerac, Marko; Trehan, Indi; Briend, André (21 December 2017). "Severe childhood malnutrition". Nature Reviews Disease Primers. **3** (1): 17067. doi:10.1038/nrdp.2017.67. PMC 7004825. PMID 28933421.

10. Odigwe, Chibuzo C; Smedslund, Geir; Ejemot-Nwadiaro, Regina I; Anyanechi, Chiedozie C; Krawinkel, Michael B (14 April 2010). "Supplementary vitamin E, selenium, cysteine and riboflavin for preventing kwashiorkor in preschool children in developing countries". Cochrane Database of Systematic Reviews. **2010** (4): CD008147. doi:10.1002 /14651858 .CD008147 .pub2. PMC 6599860. PMID 20393967.

11. "Malnutrition (Kwashiorkor and Marasmus) Symptoms and Treatment". The Lecturio Online Medical Library. 2017. Retrieved 27 July 2021.

12. "Protein energy malnutrition classification - wikidoc". www. wikidoc.org. Retrieved 29 July 2021.

13. Bender, David A., ed. (29 January 2009). "Welcome classification". A Dictionary of Food and Nutrition. OUP Oxford. ISBN 978-0-19-157975-2.

14. Gernaat, H.; Voorhoeve, HW (1 April 2000). "A new classification of acute protein-energy malnutrition". Journal of Tropical Pediatrics. **46** (2): 97–106. doi:10.1093/tropej/46.2.97. PMID 10822936.

15. Briend A (2014). "Kwashiorkor: still an enigma – the search must go on" (PDF). Emergency Nutrition Network. Retrieved 2 August 2019.

16. G. Coulthard, Malcolm (13 May 2015). "Oedema in kwashiorkor is caused by hypo albuminaemia". Pediatrics and International Child Health. **35** (2): 83–89. doi:10. 1179/2046905514Y.0000000154. PMC 4462841. PMID 25223408.

17. Pham, Thi-Phuong-Thao; Tidjani Alou, Maryam; Bachar, Dipankar; Levasseur, Anthony; Brah, Souleymane; Alhousseini, Daouda; Sokhna, Cheikh; Diallo, Aldiouma; Wieringa, Frank; Million, Matthieu; Raoult, Didier (December 2019). "Gut Microbiota Alteration is characterized by a Proteobacteria and Fusobacteria Bloom in Kwashiorkor and a Bacteroidetes Paucity in Marasmus". Scientific Reports. **9** (1): 9084. Bibcode:2019NatSR...9.9084P. doi:10.1038/s41598-019-45611-3. PMC 6591176. PMID 31235833.

18. Smith, Michelle I.; Yatsunenko, Tanya; Manary, Mark J.; Trehan, Indi; Mkakosya, Rajhab; Cheng, Jiye; Kau, Andrew L.; Rich, Stephen S.; Concannon, Patrick; Mychaleckyj, Josyf C.; Liu, Jie; Houpt, Eric; Li, Jia V.; Holmes, Elaine; Nicholson, Jeremy; Knights, Dan; Ursell, Luke K.; Knight, Rob; Gordon, Jeffrey I. (February 2013). "Gut Microbiomes of Malawian Twin Pairs Discordant for Kwashiorkor". Science. **339** (6119): 548–554. Bibcode: 2013Sci. 339. 548S. doi:10.1126/science.1229000. PMC 3667500. PMID 23363771.

19. Velly H, Britton RA, Preidis GA (2017). "Mechanisms of cross-talk between the diet, the intestinal microbiome, and the undernourished host". Gut Microbes. **8** (2): 98–112. doi:10.1080/19490976.2016.1267888. PMC 5390823. PMID 27918230.

20. "Mortality and Burden of Disease Estimates for WHO Member States in 2002" (xls). World Health Organization. 2002.