

Formulation and Evaluation of Multivitamin Gummies

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Abstract: *A multivitamin is a medication intended to serve as a salutary supplement with vitamins, salutary minerals, and other nutritive rudiments. Multivitamin formula contain vit C, B2, Zinc, Calcium, Magnesium, Potassium. gummy vitamins are designed to be a further palatable(read sweeter) volition to regular vitamins in the expedients that people will be more inclined to take them. numerous people prefer sticky vitamins to capsules due to their gooey flavours and delicacy- suchlike taste. Dissolvable, chewable, greasepaint or sticky vitamins tend to be easier to digest. Like capsules and capsules, gummies supply the vitamins. Vitamin C and Vitamin B2(riboflavin) are the idol constituents of multivitamin gummies, both gives the antioxidant exertion, Photoprotection, crack mending, ameliorate hair growth and remedial uses on eye related conditions, migraine and exertion on healthy skin/ hair independently. Citric acid have defensive goods in the body. It's used in sticky, can kill bacteria and lower the acid in urine. Agar is extensively used as gelling, thickening, stabilizing and density controlling agent for gummies. Pure honey is a enhancing agent that makes gummies delicious to eat. Orange juice shows antioxidant exertion and gives delicious flavour to sticky.*

Keywords: Vitamin C, Riboflavin, Multivitamin, Antioxidant, Gummies, Agar, Salutary Minerals

I. INTRODUCTION

Vitamin history really took off during the rest of the 1920s and into the '30s, as further nutrients were proved and further multivitamin- type products came available. "resoluteness," "vigor," and "vim" were promoted benefits. Vitamin constituents were being uprooted from food, but in the late 1930s, styles were developed to synthesize them in a lab, cutting costs and setting the stage for wider use. The result was the first set of government- patronized Recommended Dietary Allowances (RDAs) for six vitamins and two minerals. 1941 Vitamins A, B1, B2, B3, C, and D, calcium, and iron. • 1968 Vitamins E, B6, and B12, and magnesium join the list, and more are added in after times. • moment Vitamins A, B1(thiamin), B2(riboflavin), B3(niacin), B5(pantothenic acid), B6(pyridoxine,) B7(biotin), B9(folic acid), B12(cobalamin), C, D, E, K, choline, calcium, chromium, bobby , iodine, iron, magnesium, manganese, molybdenum, phosphorus, selenium, zinc, potassium, and chloride. A multivitamin is a medication intended to serve as a salutary supplement with vitamins, salutary minerals, and other nutritive rudiments. similar medications are available in the form of tablets, capsules, pastilles, maquillages, liquids, or injectable phrasings.

Gummy vitamins are designed to be a further palatable(read sweeter) volition to regular vitamins in the expedients that people will be more inclined to take them. numerous people prefer gummy vitamins to capsules due to their gooey flavors and delicacy- suchlike taste. This is one of the reasons why they appeal to children who may else be picky eaters (6). In addition, gummy vitamins are easy to bite and can generally be taken by people who have difficulty swallowing capsules. gummy vitamins are easier on the stomach because Tablets tend to be harder to digest due to the binding agent used to hold them together, Dr. Lee explains. Dissolvable, chewable, greasepaint or sticky vitamins tend to be easier to digest. Like capsules and capsules, gummies can supply the vitamin, minerals, or sauces that might be missing from your diet. The difference is that gummies are chewable, easy to swallow, and delicious!

II. MATERIALS AND METHODS

1. **Vitamin C:** Vitamin C also known as ascorbic acid(AA) is an essential nutrient in numerous multicellular organisms, especially in humans. Ascorbic acid is a water answerable vitamin and is set up in variable amounts in fruits and vegetables and organ flesh (e.g. liver and order). Deficiency of vitamin C causes scurvy, wide connective towel weakness and capillary fragility. Among druggists, it's used as a reagent

for the medication of fine chemicals, enzymatic reagent and nanomaterials. Accordingly, the discovery and quantification of ascorbic acid in food samples, products and nutraceuticals is entering inviting significance among experimenters, medical interpreters and also in the medicinal and food assiduity.

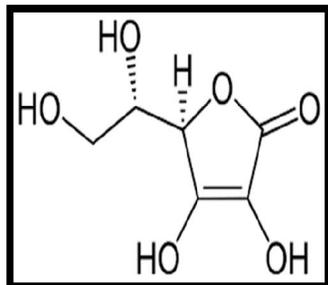


Fig. 1 Structure of vit C

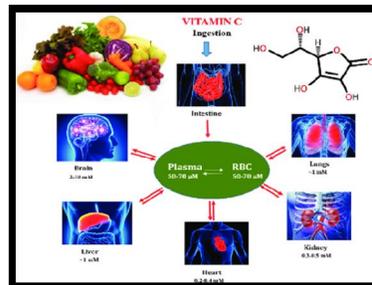


Fig. 2 Sources & multinational role of Vit C

- Vitamin B2 (Riboflavin):** Riboflavin is present in foods substantially (80 – 90) as style and FMN cofactors of proteins. Hydrochloric acid from the stomach readily releases the flavins that are only approximately bound to their proteins. A small chance of food flavin is bound to a histidyl- nitrogen or cysteinyl- sulfur and proteolysis results in the release of amino acid- linked 8- nascence- style which is biologically inactive.
- Zinc:** Zinc is a nutrient that people need to stay healthy. Zinc is set up in cells throughout the body. It helps the vulnerable system fight off overrunning bacteria and contagions. The body also needs zinc to make proteins and DNA, the inheritable material in all cells. During gestation, immaturity, and non age, the body needs zinc to grow and develop duly. Zinc also helps injuries heal and is important for proper senses of taste and smell.
- Citric acid:** product by face turmoil was started in 1923, while deep turmoil in 1930. Citric acid produced in 1929 was 5000 tons, which has increased to 4.0 lakhs tons by 1992. Sixty percent of citric acid produced is used in food and libation assiduity as a flavouring agent and preservative, while 10 in pharmaceutical assiduity in the form of iron citrate, about 25 of citric acid is used in chemical assiduity.
- Agar-Agar:** Agar and agarose forms thermo- reversible gels. Gel forming capability and solubility of agar polysaccharides calculate on relative hydrophobicity of introductory repeating unit and negotiations of the repeating units (Lahaye and Rochas, 1991). Gelatinizing and melting temperatures are varied with chemical nature. Agar from Gelidium has melting temperature between 80- 90 °C and gelatinizing temperatures between 28- 31 °C.
- Honey:** Honey has been used by humans since ancient times, nearly 5500 times agone. Utmost ancient population, including the Greeks, Chinese, Egyptians, consumed honey both for nutritive points and for its medicinal properties. Honey is the only nonentity- deduced natural product, and it has nutritive, ornamental, remedial, and artificial values. Honey is reviewed as a balanced diet and inversely popular for manly and womanish in all periods.
- Orange juice:** Because of its antioxidant and anti-inflammatory parcels, orange juice holds the pledge of cancer chemo preventive exertion.

III. FORMULATION

3.1 Formula



Quantity per serving		As per ICMR	
Energy	805 kcal	-	-
Sugar	1.250 g	-	-
Total carbohydrates	192 g	-	-
Fibers	200 mg	-	-
Vi C	30 mg	80 mg/day	-
Vi B2	1 mg	1.2 mg/day	-
Zinc	1.87 mg	7 mg/day	-

Fig. 3 Formula for multivitamin gummies
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3.2 Preparation of Chemicals & Ingredients

1. **Vit C:** Counted 30 gm. vitamin c tablet and grind and crush it with the help of mortar and pestle. Made a fine greasepaint.
2. **Vit B2 (riboflavin):** Pure riboflavin greasepaint from the pharmaceutical laboratory.
3. **Agar Agar gel:** Making an agar gel takes just a many way. First dispersing the agar 150gm in the seasoned liquid (orange juice) and making a gel using a whisk. Also bringing the liquid to a pustule for 3 to 5 twinkles. And gel gets set.
4. **Citric acid:** Dissolving 2.0 g of citric acid monohydrate in about 10 ml of water, adulterated with water to 30 ml, and blend.
5. **Collection of Honey:** Pure honey is collected by the ethnical peoples from Ratanwadi ethnical area, Akole.

3.3 Formulation of Multivitamin Gummies

1. Two idol constituents i.e. vit c and vit b2 are amalgamated and mix with sufficient quantum of water.
2. Prepared agar gel of orange flavour is mixed with pure honey for gel base.
3. The liquid vitamins and gel are mixed to each other and liquid citric acid is added to it. All constituents mixed well.
4. Putting the medication in heart shaped mould. (mould is carpeted with comestible oil painting)
5. After the freez drying for 2 days, gummies are removed from mould, tested and packaged in suitable material.



Fig. 4. Multivitamin gummies

Uses of Gummies:

1. Multivitamin gummies ameliorate the texture of skin, hair and nails fluently.
2. These gummies can indeed help to ameliorate energy situations and perform day to day tasks with complete energy.
3. Prevents acne, rich in citric acid, oranges help control acne, removes papules.
4. Controls skin ageing, fights against flights.
5. Antioxidant parcels, moisturises the skin.
6. Riboflavin prevent eye related diseases, migraine & elevated blood pressure.
7. Riboflavin is known to increase energy situations, boost functions of the vulnerable system and help maintain healthy hair, skin and nails. "Riboflavin plays a pivotal part in hair growth by cranking vitamin B6 and niacin.

Recommended Operation

Take one gummy or as directed by healthcare professional. NOT FOR MEDICINAL USE.
Don't exceed the recommended lozenge.

IV. EVALUATION SCREENING OF GUMMY VITAMIN

4.1 DCPIP Test for Vit C

DCPIP is a colour. It's blue colour when in oxidizing form and tint less in reduction form. When DCPIP is added into vitamin C result, the vitamin C reduces the colour, also decolorizes the colour. If the decolorization of DCPIP that indicates the presence of vitamin C.

4.2 Vitamin C Titration

Titration is useful in quantifying the amount of vitamin C in a result. Titrations involve quantitative addition of one reagent into another to determine the amount of one of the reagents. Acid- base titrations are veritably common in chemistry, but numerous redox responses allow quantitative analysis of results through titrations. The stopping point or end point of a titration can be observed by the colour change of an index. In this trial an Iodine result is the oxidant that will reply with vitamin C. Starch- iodine complex conformation will serve as the index, changing light grandiloquent/ brown just after a slight excess of iodine is added to a vitamin C result containing bounce. Standard results having known attention of vitamin C will be used to quantify the vitamin C in authorities.

4.3 pH of the Gummy

1. Blending a gummies into invariant paste.
2. Calibrating the pH cadence and conforming the sample temperature to room temperature before measuring the pH.
3. Irrigating the pH electrode with distilled water.
4. Immersing the electrode to the gummy paste and measuring the pH.

4.4 Texture of Gummy

1. Hardness- "Figure 5" Compression test using a large ball inquiry replicated squeezing of gummy between thumb and forefinger.
 - a. relating crucial textural parcels of sticky sweets through sensitive evaluation.
 - b. Using hardness parameter to establish upper and lower forbearance for product.
2. Firmness- "Figure 6 the most common way to measure firmness is resistance to contraction. Penetrometer is used to measuring the firmness.
3. Softness-The softness is contrary to stiffness that measuring by bending length. Softness may be considered as the contrary of firmness or hardness measured by consistence tests.
4. Springiness- Springiness is measuring, by the distance of the detected height during the alternate contraction divided by the original contraction distance.

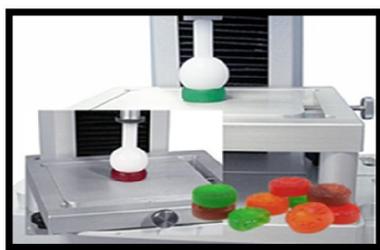


Fig. 5. Hardness tester



Fig. 6. Penetrometer

5. **Friability Testing:** "Figure7"Constantly dropping a sample of gummies over a fixed time, using a rotating barrel with a baffle. The result is examining for broken tablets, and the chance of tablet mass lost through dicing.
6. **Sensitive Analysis**
 - a. **Acceptance criteria:** Mated comparison or ranking test- The paired comparison test is simply presenting assessors with two samples, where they were asked to make a comparison between the two samples without demanding to rate the magnitude of the difference, e.g., " are the two samples same or different? " or " which of these two samples is sweeter? "
 - b. **Difference testing:** A Brace- Trio Test- is an overall difference test which will determine whether or not a sensitive difference exists between two samples. This system is particularly useful to determine whether product differences affect from a change in ingredients, processing, packaging, or storage.
 - c. **Attribute testing:** sensitive testing involves the objective evaluation of gummies by trained

mortal senses. It also involved scientific classes for testing the appearance, texture, smell and taste of a product

d. **Visual examination:** Shape – Heart shaped gummies, Size – 1.50 cm by range and 1.50 cm by length.

e. **In –Vitro Study:**

7. **Dissolution:** “Figure 8” Warming the dissolution medium i.e water to 36.5 ° to 37.5 °. Placing one lozenge unit (gummy) in the apparatus, covering the vessel and operating the apparatus at the specified rate. After 2 hours of operation in the acid medium, withdrawing an aliquot of the liquid and pacing incontinently as directed under Buffer stage.



Fig. 7. Friability tester



Fig. 8 Basket type dissolution apparatus

8. **Gummy Vitamin Absorption:** Placing a gummy in glass of water and observing the time taken for the dissolving gummies.

V. RESULT & DISCUSSION

5.1 DCPIP Test

When DCPIP is added into vitamin C result, the vitamin C reduces the colour, also decolorizes the colour. The decolorization of DCPIP indicates the presence of vitamin C.

5.2 Titration of Vit C

- a. “Figure 9” Vitamin C tablet. Left print before endpoint, added iodine reacts with ascorbic acid leaving the result colourless. Centre print at the titration endpoint all the ascorbic acid has reacted and the excess iodine reacts with the starch index to give a pale blue colour. Right print if addition of iodine is continued after the endpoint, farther iodine- starch complex is formed. NB in each of these images a beaker showing the pale blue colour of the endpoint is shown for comparison.
- b. “Figure 10” Marketable fruit juice. Left beaker before the endpoint, the colour of the result reflects the pale unheroic colour of the fruit juice. Centre beaker at the titration endpoint all the ascorbic acid has reacted and any excess iodine reacts with the starch indicator to form a dark blue-black complex. In this case the result is a darkening of the result’s colour from unheroic to brown- slate. Right beaker, This illustrates the effect of adding just a mL or two further of iodine result after the endpoint is reached, performing in the confirmation of further iodine- starch complex.

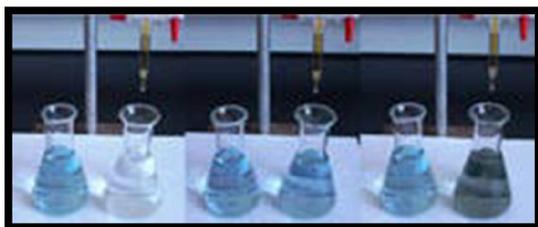


Fig. 9. Vitamin C titration



Fig. 10. Titration of marketed orange juice

c. **pH of gummy:** The pH of a 5% (w/v) gummy solution in water is 3.5 – 4.0.

d. **Texture of gummy:** “Figure 11 Gummies texture is accurately hard, soft, and springy.

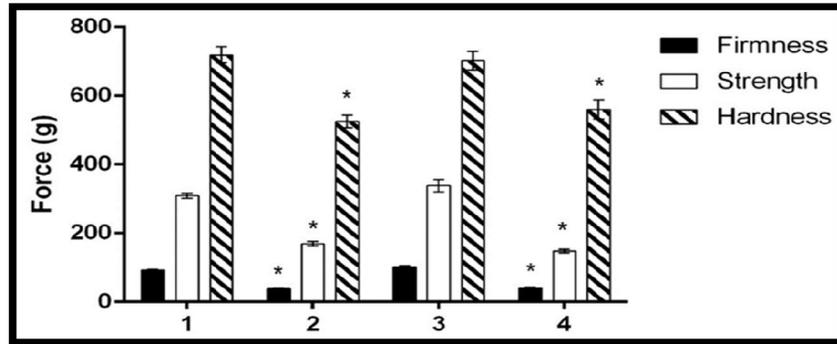


Fig no.11. Texture of gummies

e. **Sensitive analysis:** By appearance, texture, smell, taste, ranking, size, shape wise the sticky vitamin passed the acceptance criteria, difference testing, trait testing and visual examination.

f. In vitro study

A) **Dissolution of gummies:** Dissolution studies are generally used to pretend in vitro geste of the pharmaceutical tablets and to prognosticate its bioavailability and effectiveness. As can be seen in the Figure 12, expression released virtually 100 % of their content after 120 min, the performing dissolution biographies were entirely different. On the one hand, F4(orange)(R(+) CS(-)) released fast the API and attention near to 100 % after 15 min were attained, giving place to a further immediate release- suchlike profile. On the other hand, F2 (blue) (R (+) CS (-)) showed amore extended- release of vit A, D and achieving only a 60 dissolved after 45 min.

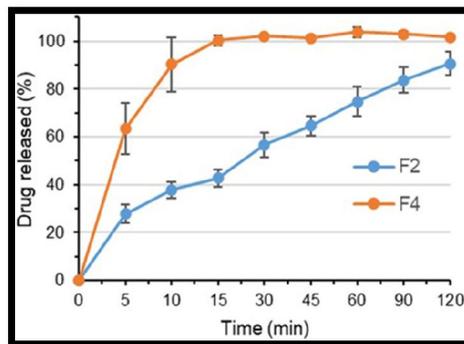


Fig. 12. Drug dissolution profile of gummy dosages

5.3 Absorption of Gummy

Studies show that a gummy vitamin and a vitamin doses have the same quantum of a vitamin, they're inversely absorbed into the bloodstream. And the dissolution time for gummy which is placed in glass of water is one and partial hour.

VI. CONCLUSION

Many people prefer gummy vitamins over capsules because they are easier to swallow, taste better, and do not have an unusual smell. They may make people more likely to take vitamins regularly. Vitamin C is an essential part of skin health both as a small molecular weight antioxidant and as a critical factor for collagen conflation. Vitamin C contributes to photo protection, decreases photo damage, and is demanded for acceptable crack mending. The colourful functions of vitamin C gummy, including the antioxidant exertion, confirmation of protein, tendons, ligaments and blood vessels, for repairing injuries and form scar tissue, for repairing and maintaining cartilage, bone, and teeth, and abetting in the absorption of iron, were exchanged. While Vitamin B2 is a water-answerable nutrient essential for breaking down fats and carbohydrates into simpler forms to enrich the body with a cure of energy for carrying out the colourful fleshly functions. Agar helps gel, stabilize, texturize and cake the gummies. Riboflavin specifically reliefs in susceptible system

and maintains healthy skin and nails. It also plays a vital part in hair growth by cranking vitamin B6 and niacin. In addition to that, this vitamin is known for being an antioxidant that destroys radicalized cells in our body.

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REFERENCES

- [1]. Sudha J. Devaki and Reshma Lila Raveendran 2017, Additional information is available at the end of the chapter <http://dx.doi.org/10.5772/intechopen.7016>.
- [2]. Food and Nutrition Board. Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. Washington, DC: National Academy Press; 2000
- [3]. Nutrient Data Laboratory. USDA National Nutrient Database for Standard Reference, Release 24 [Internet]. Available from <http://www.ars.usda.gov/ba/bhnrc/nd>
- [4]. Committee on Medical Aspects of Food Policy; 1991
- [5]. Food and Nutrition Board: Institute of Medicine; 2000
- [6]. Food and Agricultural Organization, World Health Organization; 2002
- [7]. Khan A, Rashid A, Younas R, Chong R. A chemical reduction approach to the synthesis of copper nanoparticles. *International Nano Letters*. 2016;6:21-26
- [8]. 8.Abhay Solunke, *Encyclopedia of Microbial Media* ; 2018
- [9]. 9.Ryoko Ushikoshi-Nakayama, Koufuchi Ryo, Tomoe Yamazaki, Mie Kaneko, Tomoko Sugano, Yumi Ito, Naoyuki Matsumoto, Ichiro Saito Effect of gummy candy containing ubiquinol on secretion of saliva: A randomized, double-blind, placebo-controlled parallel-group comparative study and an in vitro study; April 2019
- [10]. Cassolato SF, Turnbull RS. Xerostomia: Clinical aspects and treatment. *Gerodontology*. 2003;20: 64–77. Pmid: 14697016, View Article PubMed/NCBI Google Scholar
- [11]. Glore RJ, Spiteri-Staines K, Paleri V. A patient with dry mouth. *Clin Otolaryngol*. 2009; 34: 358–363. Pmid: 19673984, View Article PubMed/NCBI Google Scholar
- [12]. Hibberd J, Fraser J, Chapman C, McQueen H, Wilson A. Can we use influencing factors to predict aspiration pneumonia in the United Kingdom? *Multidiscip Respir Med*. 2013; 8: 39. Pmid: 23758693, View Article PubMed/NCBI Google Scholar
- [13]. Gil-Montoya JA, de Mello ALF, Barrios R, Gonzalez-Moles MA, Bravo M. Oral health in the elderly patient and its impact on general well-being: a nonsystematic review. *Clin Interv Aging*. 2015; 10: 461–467. Pmid: 25709420, View Article PubMed/NCBI Google Scholar
- [14]. Elliott C [Author] Assessing Vitamins, Minerals and Supplements Marketed to Children in Canada [Author], Published online 2019 Nov 6
- [15]. Kamangar F [Author], Vitamin and Mineral Supplements: Do We Really Need Them?, 2012 Mar; 3
- [16]. Kevin B Comerford, Recent Developments in Multivitamin/Mineral Research, November 2013. Dashora N, Sodde V, Bhagat J, Kirti SP, Labo R. Antitumor activity of *Dendrophoe falcate* against Ehrlich ascites carcinoma in Swiss albino mice. *Pharm Crops*. 2011;7:1. [Google Scholar]
- [17]. Adebolu TT. Effect of natural honey on local isolates of diarrhea causing bacteria in Southwestern Nigeria. *Afr J Biotechnol*. 2005;4:1172–4. [Google Scholar]
- [18]. Ashrafi S, Mastronikolas S, Wu CD. Use of Honey in Treatment of Aphthous Ulcers IADR/AADR/CADR 83rd General Session. Baltimore, MD., USA: 2005. pp. 9–12. [Google Scholar]
- [19]. James H. Papyrus Harris, donation to the temple of re at Heliopolis. In: Birch S, editor. *Breasted ancient records of Egypt part four pSalt 825, Egyptian magical text*. 1876. [Google Scholar]
- [20]. Bansal V, Medhi B, Pandhi P. Honey – A remedy rediscovered and its therapeutic utility. *Kathmandu Univ Med J (KUMJ)* 2005;3:305–9. [PubMed] [Google Scholar]
- [21]. Bell SG. The therapeutic use of honey. *Neonatal Netw*. 2007;26:247–51. [PubMed] [Google Scholar]

- [22]. Hassapidou M, Fotiadou E, Maglara E, Papadopoulou SK. Energy intake, diet composition, energy expenditure, and body fatness of adolescents in Northern Greece. *Obesity (Silver Spring)* 2006;14:855–62. [PubMed] [Google Scholar]
- [23]. Babacan S, Rand AG. Characterization of honey amylase. *J Food Sci.* 2007;72:C050–5. [PubMed] [Google Scholar]
- [24]. Pataca LC, Borges Neto W, Marcucci MC, Poppi RJ. Determination of apparent reducing sugars, moisture and acidity in honey by attenuated total reflectance-Fourier transform infrared spectrometry. *Talanta.* 2007;71:1926–31. [PubMed] [Google Scholar]
- [25]. Inglett GE. A history of sweeteners – Natural and synthetic. *J Toxicol Environ Health.* 1976;2:207– [PubMed] [Google Scholar]
- [26]. Ahmed S, Othman NH. Honey as a potential natural anticancer agent: A review of its mechanisms. *Evid Based Complement Alternat Med.* 2013;2013:829070. [PMC free article] [PubMed] [Google Scholar]
- [27]. Khalil I, Moniruzzaman M, Boukraâ L, Benhanifia M, Islam A, Islam N, et al. Physicochemical and antioxidant properties of Algerian honey. *Molecules.* 2012;17:11199–215. [PMC free article] [PubMed] [Google Scholar]
- [28]. Attia WY, Gabry MS, El-Shaikh KA, Othman GA. The anti-tumor effect of bee honey in Ehrlich ascite tumor model of mice is coincided with stimulation of the immune cells. *J Egypt Public Health Assoc.* 2008;15:169–83. [PubMed] [Google Scholar]
- [29]. Estevinho L, Pereira AP, Moreira L, Dias LG, Pereira E. Antioxidant and antimicrobial effects of phenolic compounds extracts of Northeast Portugal honey. *Food Chem+ Toxicol.* 2008;46:3774–9. [PubMed] [Google Scholar]
- [30]. Abdulrhman M, El-Hefnawy M, Ali R, El-Goud AA. Honey and type 1 diabetes mellitus. In: Liu CP, editor. *Type Diabetes – Complications, Pathogenesis, and Alternative Treatments.* Croatia: In Tech; 2008. [Google Scholar]
- [31]. Ghosh S, Playford RJ. Bioactive natural compounds for the treatment of gastrointestinal disorders. *Clin Sci (Lond)* 2003;104:547–56. [PubMed] [Google Scholar]
- [32]. Mijanur Rahman M, Gan SH, Khalil MI. Neurological effects of honey: Current and future prospects. *Evid Based Complement Alternat Med.* 2014;2014:958721. [PMC free article] [PubMed] [Google Scholar]
- [33]. Newman TG. *Honey Almanac.* Chicago, IL: Newman; 1983. [Google Scholar]
- [34]. Molan PC. The potential of honey to promote oral wellness. *Gen Dent.* 2001;49:584–9. [PubMed] [Google Scholar]
- [35]. Bergman A, Yanai J, Weiss J, Bell D, David MP. Acceleration of wound healing by topical application of honey. An animal model. *Am J Surg.* 1983;145:374–6. [PubMed] [Google Scholar]
- [36]. Irving TB, Ahmad K, Ahsan MM. *The Qur'an-Basic Teachings.* Ch. 5. Bath: Pitman Press; 1987. The story of creation. [Google Scholar]
- [37]. Lay-flurrie K. Honey in wound care: Effects, clinical application and patient benefit. *Br J Nurs.* 2008;17:S30, S32–6. [PubMed] [Google Scholar]
- [38]. Betts J. The clinical application of honey in wound care. *Nurs Times.* 2008;104:43–4. [PubMed] [Google Scholar]
- [39]. Helmy N, El-Soud A. Honey between traditional uses and recent medicine. *Maced J Med Sci.* 2012;5:205–14. [Google Scholar]
- [40]. White JW. *Composition of American Honeys.* Washington, DC, USA: Agricultural Research Service, USDA; 1962. [Google Scholar]
- [41]. White JW., Jr Detection of honey adulteration by carbohydrate analysis. *J Assoc Off Anal Chem.* 1980;63:11–8. [PubMed] [Google Scholar]
- [42]. Islam A, Khalil I, Islam N, Moniruzzaman M, Mottalib A, Sulaiman SA, et al. Physicochemical and antioxidant properties of Bangladeshi honeys stored for more than one year. *BMC Complement Altern Med.* 2012;12:177. [PMC free article] [PubMed] [Google Scholar]
- [43]. Manyi-Loh CE, Clarke AM, Ndip RN. Identification of volatile compounds in solvent extracts of honeys produced in South Africa. *Afr J Agric Res.* 2011;6:4327–34. [Google Scholar]

- [44]. Sato T, Miyata G. The nutraceutical benefit, part iii: Honey. *Nutrition*. 2000;16:468–9. [PubMed] [Google Scholar]
- [45]. Abrams SA, Wen J, Stuff JE. 1997. Absorption of calcium, zinc, and iron from breast milk by five- to seven-month-old infants. *Pediatr Res* 41:384–390. [PubMed]
- [46]. Aggett PJ. 1989. Severe zinc deficiency. In: Mills CF, editor. , ed. *Zinc in Human Biology* . New York: Springer-Verlag. Pp.259–279.
- [47]. Alexander D, Ball MJ, Mann J. 1994. Nutrient intake and haematological status of vegetarians and age-sex matched omnivores. *Eur J Clin Nutr* 48:538–546. [PubMed]
- [48]. Alexander FW, Clayton BE, Delves HT. 1974. Mineral and trace-metal balances in children receiving normal and synthetic diets. *Quart J Med* 169:89–111. [PubMed]
- [49]. Allen JC, Keller RP, Archer P, Neville MC. 1991. Studies in human lactation: Milk composition and daily secretion rates of macronutrients in the first year of lactation. *Am J Clin Nutr* 54:69–80. [PubMed]
- [50]. Anderson BM, Gibson RS, Sabry JH. 1981. The iron and zinc status of long-term vegetarian women. *Am J Clin Nutr* 34:1042–1048. [PubMed]
- [51]. Anderson RR. 1993. Longitudinal changes of trace elements in human milk during the first 5 months of lactation. *Nutr Res* 13:499–510.
- [52]. Aquilio E, Spagnoli R, Seri S, Bottone G, Spennati G. 1996. Trace element content in human milk during lactation of preterm newborns. *Biol Trace Elem Res* 51:63–70. [PubMed]
- [53]. Artacho R, Ruiz-Lopez MD, Gamez C, Puerta A, Lopez MC. 1997. Serum concentration and dietary intake of Zn in healthy institutionalized elderly subjects. *Sci Total Environment* 205:159–165. [PubMed]
- [54]. August D, Janghorbani M, Young VR. 1989. Determination of zinc and copper absorption at three dietary Zn-Cu ratios by using stable isotope methods in young adult and elderly subjects. *Am J Clin Nutr* 50:1457–1463. [PubMed]