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Review Article

Healthy Pregnancy with Potato: A Review

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Abstract

Carbohydrate, protein, lipid, mineral, vitamin and water are the essential nutrients and when they are present in correct amount which is required by the body is called optimum nutrition, adequate nutrition or balanced diet. A poor diet may import an injurious impact on health, like-: It causes deficiency diseases like scurvy and kwashiorkor; Health-threatening conditions like obesity, metabolic syndrome; Common chronic systemic diseases i.e. cardiovascular disease, diabetes and osteoporosis. Nutritional requirement changes during the different stages of a life span. Pregnancy is the stage when nutritional needs are higher and full feeling those needs import positive effects on the health of both mother and her unborn baby. Importance of a balance diet is emphasized especially in terms of quality of carbohydrates taken in pregnancy and lactation. So the present article puts light on the use of potato as a high carbohydrate food which is consumed daily by plenty of people in our Indian houses. Along with that it has valuable antioxidant and medicinal properties, with little or no side effects and is within affordable price even to the people of below poverty line. In this review article we surmised the role of potato as a high carbohydrate diet during gestation and lactation.

Keywords

Body mass index

Carbohydrate

Gestation

Nutrition

Placental transport

Introduction

Worldwide major cause of ill-health is over-nutrition, under-nutrition or unbalance nutrition (Tzanetakou, et al., 2011). Every year around more than 20 million infants are born with low birth weight (Akin et al., 2010). More than one-third of child deaths are due to maternal and child under nutrition (Black et al., 2008). For example, a low fat diet during pregnancy and lactation helps to prevent metabolic disturbances in the offspring of obese mice with type 2 diabetes mellitus (Gallou-Kabani et al., 2007). Pregnancy is a stressful period for the entire organism (Scholtes, 1979). In pregnant women correlation exist between diets, health and outcomes of their pregnancies (Hoet and Hanson, 1999). Fig. 1 shows the importance of maternal nutrition in metabolic programming of fetus. Pregnancy is the stage when food requirement of the body increases for the proper development of the

baby and for the mother's health (Miese-Looy et al., 2008). Understanding the physiological regulation of nutrient uptake helps in preventing abnormal conditions like diabetes and obesity on intestinal absorption (Balakrishnan et al., 2012). Details of recommended dietary allowance are described in Table 1.

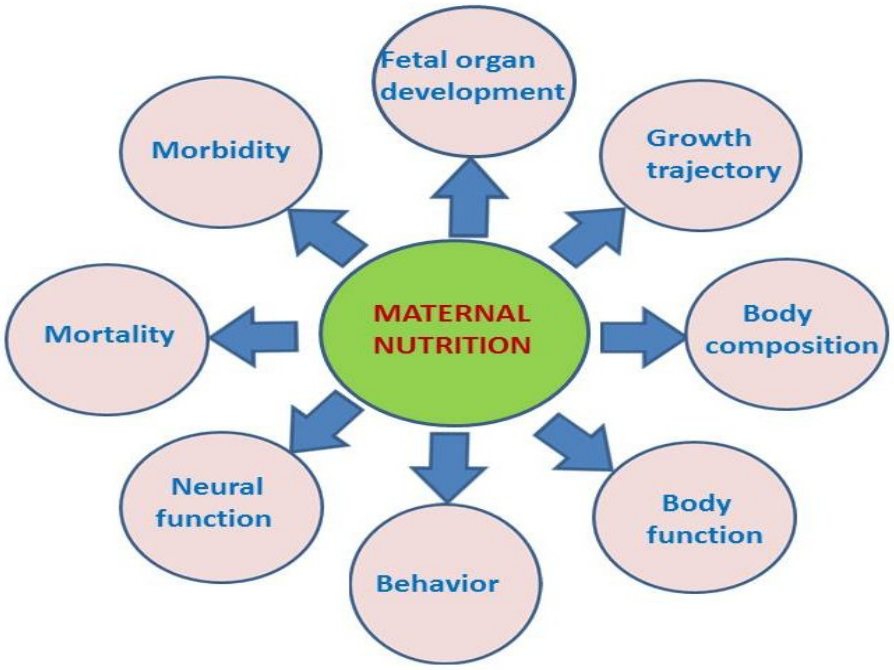
Table 1. Recommended allowance (mg/day).

Components	Adult	Pregnancy	Lactation	Infants	Children's
Folic Acid	100	400	150	25	30-100
Vitamin B12	1.0	1.0	1.5	0.2	0.2-1.0
Vitamin C	40	40	80	25	40
Calcium	400	1000	1000	500	400
Phosphorus	400	1000	1000	750	400
Iron	28-30	38	30	1.0	12-40
Source: BY ICMR Expert Committee (1986).					

Table 2. Placental transport on nutrients present in potato.

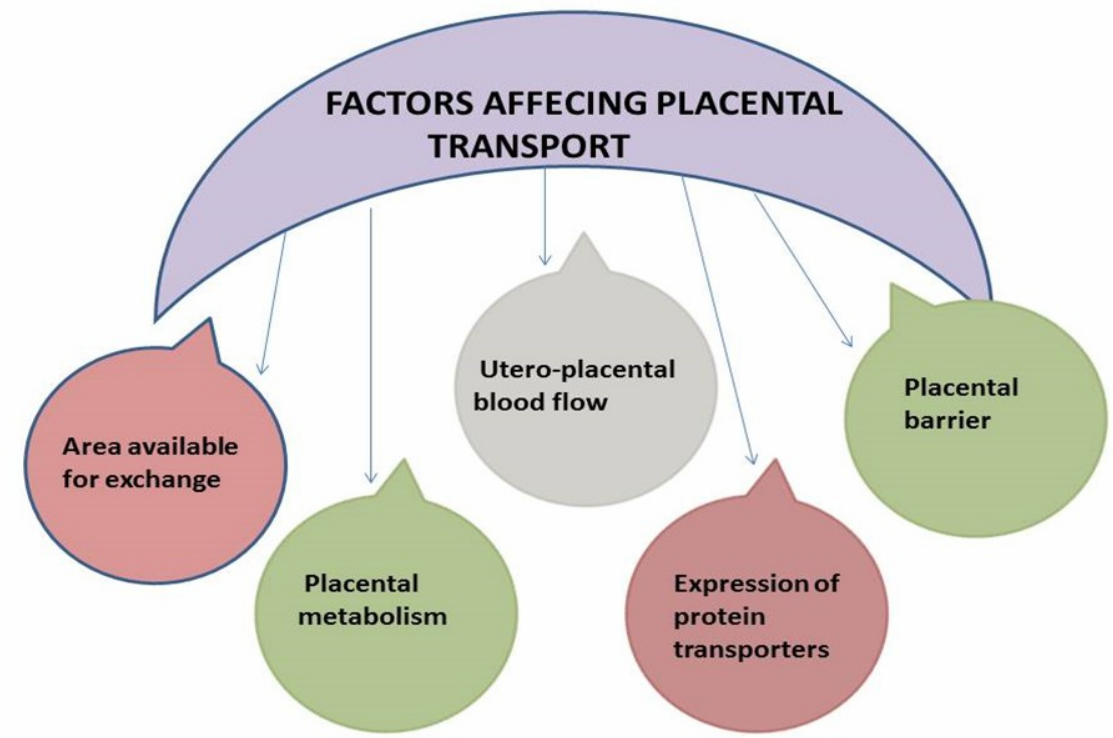
Nutrients	Function	Placental transport	References
Glucose	Main metabolic fuel for fetus	Carrier mediated diffusion via GLUT	(Lager and Powell, 2012)
Calcium	Maintain bone density	Simple diffusion	(Stulc and Stulcova, 1986)
Iron	Scavenging radical, activate antioxidant enzyme and inhabit oxidases	Maternal blood bound transferrin via Tf receptors	(Nadadur et al., 2008)
Magnesium	Active metal for many metabolic enzymes.	Active transportation	(Dancis et al., 1971)
Phosphorus	Maintains urinary pH	Active transportation	(Economou-Mavrou and McCance, 1958)
Thiamin	Normal growth and development of fetus, lactation.	With the help of cinnamic acid	(Keating et al., 2006)

Fig. 1: Showing dependence of fetal development on maternal nutrition.



MATERNAL NUTRITION AND METABOLIC PROGRAMMING OF FETUS

Fig. 2: Showing factors which effects placental transport.



Volume of milk production is also influence by inadequate nutrients and energy intake, and this is a possible cause of breastfeeding malnutrition, or "failure to thrive" in the infant (Labuschagne et al., 2012). Pregnant as well as lactating women require more essential nutrients as compare to other women. Their body needs an additional 300 calories each day to support the growth of the baby, hence it is important to eat the nutritious foods because tissues and organs develop during certain weeks of pregnancy and the baby is always growing (Foster, 2009).

HEALTH OF FETUS ∝ NUTRITIONAL,

The present review article is a trial to understand the effect of potato as a high carbohydrate ingredient during pregnancy and lactation. It also summarizes the research done on the placental transport of nutrients present in potato.

Placental transportation

All food, liquids, medications and other substances that the mothers have, pass through the placenta to the developing fetus. Fetal growth is largely depends on nutrient supply, which is dependent upon the placental nutrient transport. Several factors influence the transport across placenta: i.e. uteroplacental and umbilical blood flows, area available for exchange, placental metabolism, and activity/expression of specific transporter proteins in the placental barrier (Lager and Powell, 2012). Diagrammatic representation of factors affecting placental flow is in Fig. 2. Transfer of highly permeable molecules like oxygen and carbon dioxide is particularly influenced by reduced blood flow (Carter, 2009). Placental transport of nutrients present in potato in summarized in Table 2.

Carbohydrate and pregnancy

Due to fetal growth and increase in maternal body weight, energy requirement increases during pregnancy (Brown, 2005b). 50-65% of total energy intake comes from carbohydrate and daily approx. 175g during pregnancy and 210g during breastfeeding is important to meet the fetal brains glucose requirement (Shaya et al., 2008).

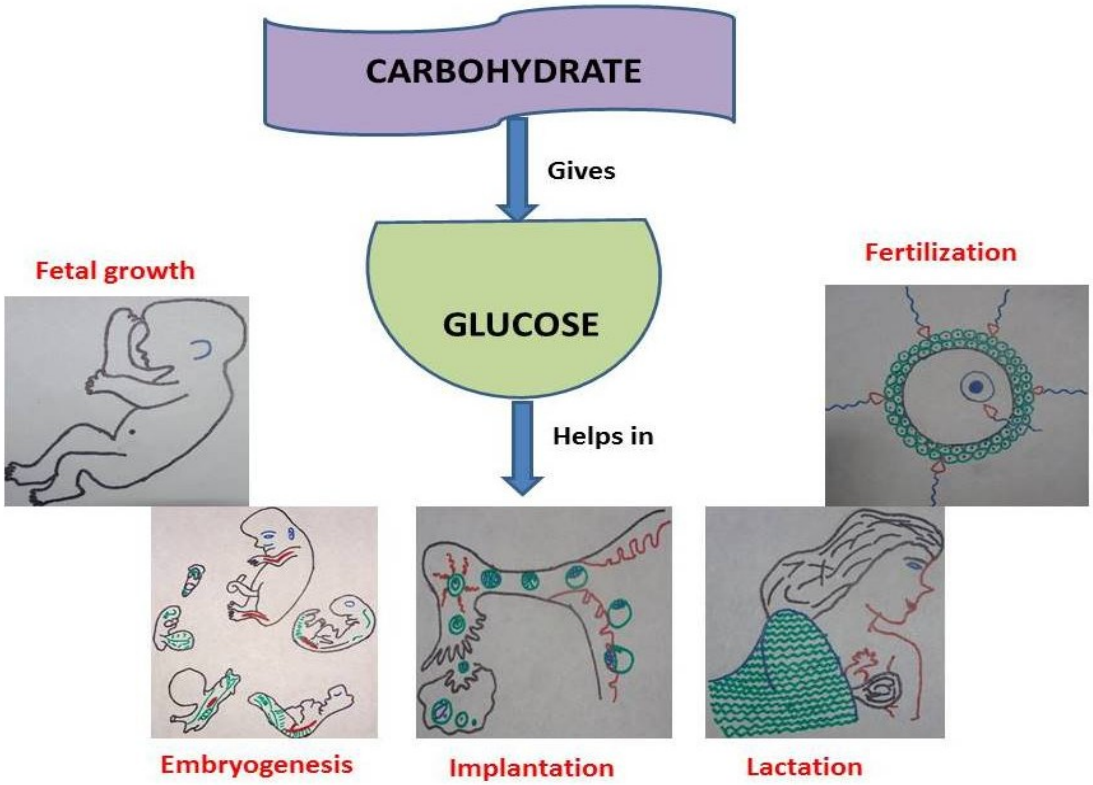
The importance of a balance diet is emphasized especially in terms of quality of carbohydrates taken in

pregnancy and lactation and the risk of developing insulin resistance and obesity is reduce by replacing low fiber grain food, such as cornflakes or white bread with whole grain higher fiber or higher amylose content products (Tzanetakou et al., 2011). Main sources of carbohydrates are given in Table 3.

Table 3. Main sources of carbohydrates.

Main sources of carbohydrates	Source
Starches	Rice, wheat, maize, sago, all bakery products
Sugars	Cane sugar, jiggery, honey, dry fruits, fresh fruits
Cellulose	Whole grains, whole pulses

Fig. 3: Showing importance of carbohydrate in human development.



Carbohydrates are the major constituent of human diet, carbohydrate rich food is digested easily and provide large amount of energy and is also consider good for sick and old age peoples (Shaya et al., 2008). Having low-carbohydrate, high-protein hypocaloric diet leads to the development of optic neuropathy from thiamine deficiency (Hoyt and Billson, 1977). Children having low carbohydrate ketogenic diets have reduced intakes of calcium, magnesium, and iron (Tallian et al., 1998).

The American Diabetes Association, The American Heart association and other national agencies from 1950's recommend that large portion of energy comes from carbohydrates (ADA, 2000; USDA, 2005). Dietary Guidelines for Americans recommend that 45 to 65% of the calories people consume each day should come from carbohydrate.

At low glucose level fertilization and implantation occur but embryogenesis did not continue instead of that resorption of embryo occur (Koski et al., 1986). Fig. 3 shows the importance of carbohydrate in developmental processes. Glucose is one of the most studied macronutrient in respect to fetal development because it is a primary energy source (Miese-Looy et al., 2008). Glucose is consider as an perfect fuel for fetal growth and development and glucose is a substrate which is primarily affected by the amount and type of carbohydrates in maternal diet (Reynolds et al., 2007).

As fetus grows rapidly during the second half of gestation, hence glucose requirement increases (Hay, 2006). Glucose, as a source of energy, is important for production and reproductive performance of an organism (Sutton-McDowall et al., 2010). Oleic acid based zero carbohydrate diet does not able to maintain pregnancy, thus it shows the requirement of carbohydrate in pregnancy (Koski and Hill, 1986).

Feeding pregnant rats with carbohydrates free and fatty acid based diet from 1st day of gestation leads to resorption of implanted embryos (Taylor et al., 1983). Glucose and galactose from carbohydrate synthesize lactose by de novo synthesis in breast; this process is called as hexoneogenesis (Sunehag et al., 2002). Galactose which is a potential substrate for lactose synthesis also promotes fat mobilization and oxidation (Sunehag et al., 2003).

Imbalance in animal protein and carbohydrate intake by pregnant lady is related with raised in systolic and diastolic blood pressures in the offspring (Shiell et al., 2001). Women who consume high animal-protein, low carbohydrate diet in pregnancy shows higher adult blood pressure in the offspring (Shiell et al., 2001). Women who consume small amount of carbohydrate rich food in late pregnancy have lower weight gain (Shiell et al., 2001). Romson et al. (1981) observes normal growth and development in dogs fed with carbohydrate-free triglyceride, but survival of fetuses was lower than the dogs which fed with high carbohydrate diet.

How much carbohydrate food raise blood glucose level as compare with standard carbohydrate i.e. glucose is called as glycemic index (Jenkins et al., 1981). Glycemic index directly depends on the digestion rate and rapidity of carbohydrates absorption (Hallfrisch et al., 2000). Glycemic load is the product of glycemic index and the value of carbohydrate content in food, glycemic lode represents both quality and quantity of carbohydrate consumes (Vetter et al., 2010; Liu et al., 2000). Food with low glycemic index and low glycemic load is good for health (Ludwiq, 2002).

GI = Blood glucose level raise by carbohydrate food
GL= GI × total carbohydrate present in food
(Quality and quantity of carbohydrate)
Where,
GI=Glycemic Index
GL=Glycemic Load

Fig. 4: Classification and nutrient composition of potato.

Effect of potato as a high carbohydrate food

Following wheat, maize and rice, potato is one of the world's most important crops (CFIA, 2014). Both US Department of Agriculture (USAD) Food Guide Pyramid and 2005 revised; include potatoes in a vegetable category as a food to be encouraged (USDA, 2005). Many professionals and medical organizations, including American Dietetic Association and The American Heart Association state potato as a healthful food (ADA, 2005; AHA, 2005). As potato is one of the most studied high carbohydrate content food and its genome is known so there exist enormous capacity to improve potato towards an increasingly more healthy food item through breeding (Camire et al., 2009). Potatoes have greater dry matter and protein per unit growing area compared with the cereal (Bamberg and Del Rio, 2005). Classification and nutrient composition of potato are in Fig. 4.

Many studies demonstrate potato has high glycemic index (Foster-Powell et al., 2002). Glycemic index value of potato depends upon the cooking method (Foster-Powell et al., 2002; Lunetta et al., 1995; Fernandes et al., 2005). By cooking and cooling glycemic index of starchy food can be reduce; that's why cooled potato has low glycemic index as compare to potato consume immediate after cooking (Fernandes et al., 2005; Pi-Suyer, 2002). In children of age 7-8, 50% of total carbohydrate is contributed by boiled potatoes as compare to French fried potatoes and mashed potatoes which contribute 28% and 15% of carbohydrate (Fernandes et al., 2005). Nutrient composition and properties of potato is also summarized in Table 4.

Table 4. Nutrient composition and properties of potatoes.

Nutrients	Vitamins	Antioxidants	Properties
Sucrose, Glucose, Fructose, Protein, Starch, Phosphors, Magnesium, Calcium Iron, Potassium	Vitamin B6, Folic Acid, Niacin, Pyridoxine, Riboflavin, Thiamin Vitamin A	Anthocyanin Vitamin C B-carotene Xanthophyll	Prevent scurvy Energy Reserve Ant oxidative Prevent premature death Prevent blindness Maintains urinary pH

Anthocyanin's are red, blue, and purple pigments found in the skin and flesh of certain potatoes cultivars, are important in plant and human health because of its important antioxidant properties (Brown et al., 2005; Brown, 2005a; Brown, 2008). Due to biological functions like radical scavenging, anti-mutagenicity and antioxidant activity, the anthocyanin pigment of the purple potato has attracted much interest (Philpott et al., 2004; Yoshimoto et al., 2001; Kano et al., 2005). Recently, anthocyanins from edible fruits and vegetables like potatoes show to have free radical-scavenging activity (Wang et al., 1997; Lapidot et al., 1999). Boiled potato has many additional benefits like low energy density, high vitamin C, vitamin B6, folic acid, magnesium, iron content and their alkalizing effect due to their high potassium content (Bartova and Barta, 2009). According to Buckenhuskes (2005), potato prevents scurvy due to its relatively high vitamin C content. Vitamin C (ascorbic acid) is a predominant vitamin in potatoes, it is important to iron availability, which is a mineral that tends to be limiting in the human diet (Brown, 2008). Properties of potato are given in Fig. 5.

Potatoes are a good dietary source of several B vitamins (folic acid, niacin, pyridoxine, riboflavin, and thiamin) and pyridoxine (vitamin B6) (Camire et al., 2009). Deficiency of vitamin A is found in more than 124 million children around the world (Humphrey et al., 1992), which results in various ailments, including blindness, and resulting in premature death. The most abundant carotenoids are xanthophylls in potato (Brown, 2008). Yellow flesh of potato contains lutein with a trace of β-carotene and many other pigments like violaxanthin, zeaxanthin, anthocynine and others (Brown, 2008).

Sucrose and glucose and fructose are the major disaccharide and monosaccharides of potatoes (Camire et al., 2009). Compared with other vegetable, potatoes are not a good dietary protein source because of its low protein content, but potato protein has excellent biological value (BV), with a BV of 90–100 as compared to whole egg (100), soybean (84), and beans (73) (Buckenhuskes, 2005; Donnelly and Kubow, 2011). In raw potatoes minerals are present in greatest concentrations, like potassium (64), phosphorus (30–

60), calcium (6–18) (Buckenhuskes, 2005; Snowdon, 2010).

Body Mass Index (BMI)

According to The United States Centers for Disease Control and Prevention (CDC) overweight and obesity ranges are determined by using weight and height to calculate a number called the ‘‘body mass index’’ (BMI). For adults BMI is based on height and weight of an organism, and it's widely used to say who's obese, who's overweight (but not obese), who's at a normal weight, and who's underweight (Kam, 2013). BMI is a simple mathematical formula, based on height and weight and is used to measure fatness (Zelman, 2008). Effects of high BMI during adulthood and pregnancy is given in Fig. 6.

Fig. 5: Properties of potato.

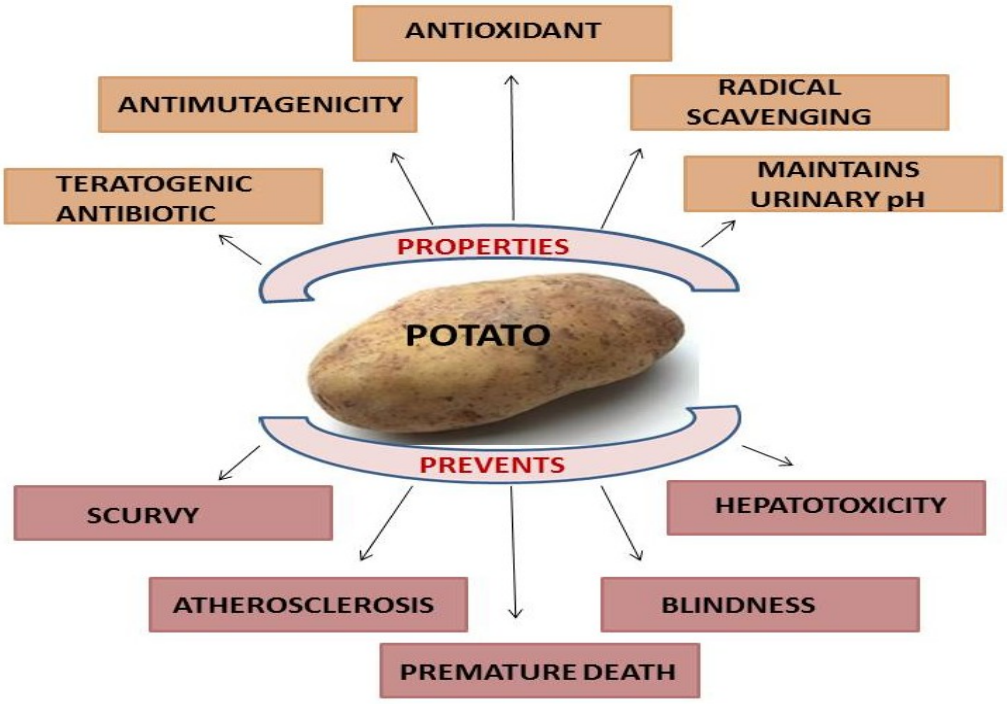
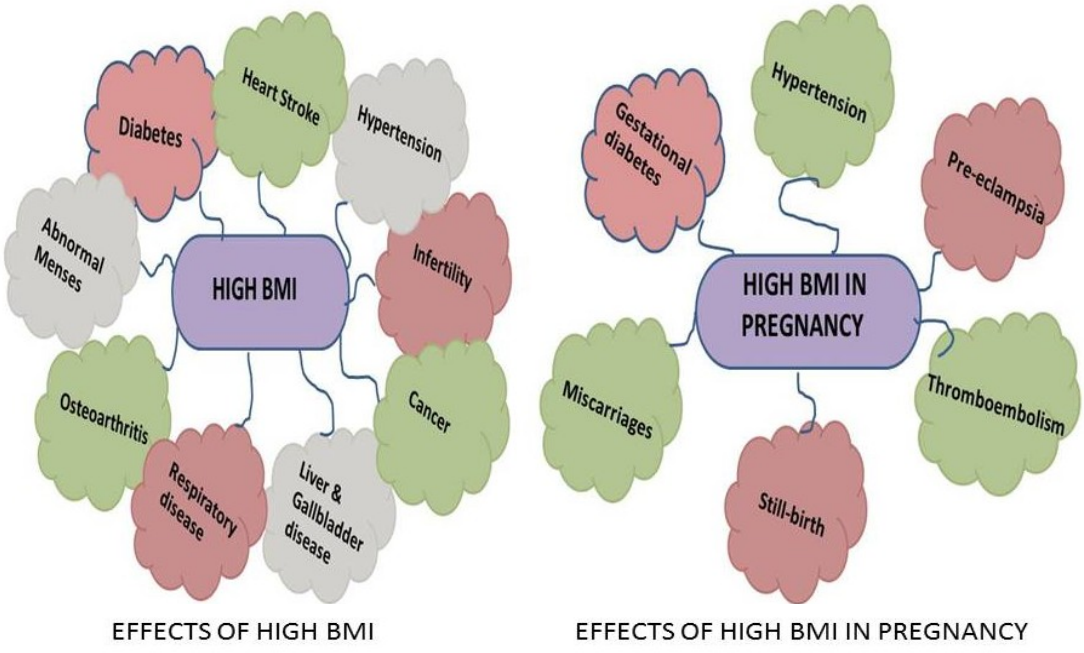


Fig. 6: Effects of high BMI during adulthood and in pregnancy.



Quetelet developed outdated BMI formula [BMI = weight in pounds/(height in inches) ×703], nearly 200 years ago is not a measurement of adiposity, but merely an imprecise mathematical estimate (Fleming and DeMets, 1996; Razak et al., 2007; Romero-Corral et al., 2008; Flegal et al., 2009; Flegal, 2010; Rahman and Berenson, 2010; Sun et al., 2010). According to Swinburn et al. (1999), "WHO Expert Consultation, 2004" Institute of Medicine, 1990 appropriate BMI cut-offs in normal adult and recommended weight gain in pregnancy are given in Table 5.

$$BMI = \frac{\text{weight (in pounds)}}{\text{height (in inches)}} \times 703$$

Table 5. Appropriate BMI cut off and recommended weight gain in pregnancy.

Classification	BMI value (kg/m)	Recommended weight gain in pregnancy
Underweight	18.5	12.5-18.0
Normal range	18.5-24.9	11.5-16.0
Overweight	25-29.9	7.0-11.0
Obese	30	6.0

Carbohydrate and BMI

High in carbohydrate diets may be adopted for successful weight management because it is both energy restrictive and nutritious (Bowman and Spence, 2002). Study done by Bowman and Spence (2002), shows that people on a high carbohydrate diet are more likely to be a healthy weight (have Body Mass Index values below 25). Result of study done by Toeller et al. (2001) shows that, in 2 cross-sectional studies, persons with type 1 diabetes (n = 2868) when consumed a diet high in carbohydrates, cereal fiber, and low-glycemic-index foods had a smaller waist circumference and BMI. Low-fat, high-carbohydrate diets have been suggested to promote weight loss in the obese (George et al., 1990; Prewitt et al., 1991; Dreon et al., 1988). High-carbohydrate diets are less energy dense, provide more bulk per KiloJoule and are more rapidly oxidized and less readily stored than are high-fat diets (Duncan et al., 1983; Horton et al., 1995; Stubbs et al., 1995; Poppitt et al., 1998).

Potato and BMI

Having potatoes for 100 days contain up to 5,000kg/ha of carbohydrate and 800kg/ha of usable protein and it also a superior sources of ascorbic acid (vitamin c) with a useful amount of thiamine, niacin, iron and phosphorus (Domek et al., 1995). In a short-term study, obese children consumed more energy after having lunch containing rapidly-digested carbohydrates like mashed potato, meat, nectar as compare to more slowly digested carbohydrates like spaghetti, meat, orange (Alvina and Araya, 2004).

Including potatoes in the diets of persons attempting weight loss is a promising method (Camire et al., 2009). Since potato has a relatively low energy density, negligible fat, quality protein, fiber, and vitamins, especially vitamin C and the B-group vitamins, minerals, especially potassium, and important phytochemicals, many of which have antioxidant properties, potato has an important role in preventing malnutrition (Camire et al., 2009). Highest potato consumption was associated with greater relative risks in obese women (BMI -30), but not for women who were not obese (BMI < 30 kg/m^2) (Camire et al., 2009).

Conclusion

From the basis of above cited reviews we conclude that the balance diet is mainly emphasize in the terms of carbohydrate. 60% of the total glucose comes from carbohydrate and this glucose is necessary for fertilization, embryogenesis, implantation, fetal growth and development, lactation etc. In between the numerous sources of carbohydrate, potato which is very commonly used in our houses, have very promising role in pregnancy. It is rich in antioxidants, vitamins, calcium, phosphors, iron etc.

Potato prevents scurvy, premature death, Prevent blindness, hepatotoxicity and maintains urinary pH and has a property of anti-mutagenicity, antioxidant, teratogenic antibiotic etc. Instead of all these numerous benefits more study is needed to illuminate the effect of potato in combination with natural antioxidants which proves beneficial for maintaining healthy pregnancy.

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