International Journal of Biological and Pharmaceutical Sciences Archive

ISSN: 0799-6616 (Online)

Journal homepage: https://ijbpsa.com/

(Review Article)

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Nutrition in pregnancy: Safe fruit and food choices, avoidances and mechanisms of deficiency

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International Journal of Biological and Pharmaceutical Sciences Archive, 2026, 11(01), 096-104

Publication history: Received on 13 January 2026; revised on 21 February 2026; accepted on 23 February 2026

Article DOI: https://doi.org/10.53771/ijbpsa.2026.11.1.0022

Abstract

Pregnancy is a critical physiological period characterized by increased nutritional demands to support maternal adaptations, placental function, and fetal growth. Fruits are an important component of prenatal nutrition, providing essential micronutrients such as vitamin C, folate, potassium, and antioxidants that contribute to immune function, hematopoiesis, neural development, and oxidative stress regulation. Adequate fruit consumption has been associated with improved pregnancy outcomes, including reduced risk of maternal anemia, enhanced fetal neurodevelopment, and favorable birth outcomes. However, concerns regarding the safety of certain fruits, particularly unripe papaya, pineapple, and grapes, have led to widespread misconceptions and unnecessary dietary restrictions. Current scientific evidence indicates that most fruits are safe when consumed in moderate amounts, and the concept of inherently teratogenic fruits is not supported by robust human data. Instead, potential risks are primarily associated with microbial contamination, pesticide exposure, or excessive intake of bioactive compounds in non-dietary forms. Avoidance of fruits without appropriate nutritional substitution may result in deficiencies of essential micronutrients, increasing the risk of adverse maternal and fetal outcomes. Clinical recommendations emphasize safe handling, proper washing, and balanced dietary intake rather than unnecessary restriction. This review highlights the importance of fruits in pregnancy, evaluates safety concerns, and provides evidence-based recommendations to optimize maternal and fetal health outcomes.

Keywords: Pregnancy Nutrition; Fruit Consumption; Maternal Health; Fetal Development; Food Safety in Pregnancy; Micronutrient Deficiencies; Teratogenicity Myths

1. Introduction

Pregnancy is a complex physiological state characterized by profound metabolic, endocrine, and anatomical adaptations that support fetal growth, placental development, and maternal tissue expansion. These changes substantially increase maternal nutritional requirements to meet the demands of rapid cellular proliferation, organogenesis, and maternal physiological adjustments. Inadequate or imbalanced dietary intake during pregnancy is strongly associated with adverse outcomes, including low birth weight, preterm birth, congenital anomalies, and impaired neurodevelopment [1,2].

Protein and amino acids play a pivotal role in fetal tissue accretion, placental growth, and expansion of maternal blood volume. Emerging evidence indicates that protein requirements during pregnancy may be higher than earlier estimations, underscoring the need for adequate intake to optimize maternal and fetal outcomes [3,4]. Beyond

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macronutrients, essential micronutrients such as iron, folate, calcium, iodine, vitamin D, and multiple micronutrients are critical for immune competence, neural tube formation, skeletal development, and metabolic regulation. International expert consultations and global health authorities emphasize the importance of ensuring sufficient micronutrient intake during pregnancy to prevent maternal anemia, fetal growth restriction, and perinatal complications [4,5].

The concept of the Developmental Origins of Health and Disease (DOHaD) further highlights the long-term consequences of maternal nutrition. Barker's hypothesis proposes that nutritional exposures during critical windows of fetal development influence susceptibility to chronic diseases later in life, including obesity, diabetes, and cardiovascular disorders [6]. Thus, maternal nutrition represents not only a determinant of immediate pregnancy outcomes but also a modifiable factor influencing lifelong health trajectories.

Recognizing the importance of maternal diet, the World Health Organization (WHO) recommends nutritional interventions during antenatal care, including multiple micronutrient supplementation to improve maternal and neonatal outcomes [5]. However, despite growing awareness, comprehensive and consistently graded evidence defining optimal nutritional strategies throughout the reproductive continuum—from preconception through pregnancy and lactation remains limited. Proceedings from the National Academies of Sciences, Engineering, and Medicine have emphasized the need for further high-quality research to refine evidence-based dietary recommendations during these critical stages [7].

Recent systematic reviews conducted under the Pregnancy and Birth to 24 Months Project have evaluated the associations between dietary patterns and maternal as well as birth outcomes [8–10]. These analyses suggest that dietary patterns rich in fruits, vegetables, whole grains, lean proteins, and healthy fats are associated with improved maternal metabolic profiles and favorable birth outcomes. Nevertheless, many nutrition-related questions remain supported by limited or moderate evidence, indicating important research gaps. Additionally, infant milk-feeding practices have been linked to long-term metabolic outcomes in offspring, reinforcing the importance of nutritional continuity from pregnancy through early life [11].

Traditional dietary models emphasizing balanced intake of whole foods are commonly recommended due to their established benefits [1,12]. Concurrently, alternative dietary patterns, including vegetarian and other restrictive diets, have gained popularity, necessitating careful evaluation of their nutritional adequacy during pregnancy. Furthermore, with the rising prevalence of gestational diabetes mellitus, understanding the influence of dietary composition on glycemic control is critical for minimizing both short- and long-term maternal and fetal complications [2,9]. Given the heightened metabolic demands of pregnancy and the profound implications of maternal diet for both immediate and future health outcomes, food during pregnancy should be regarded as a central therapeutic and preventive strategy. A comprehensive understanding of nutrient requirements, dietary patterns, and evidence-based recommendations is essential to optimize maternal well-being and ensure healthy fetal development. This review aims to critically examine the importance of nutrition during pregnancy, evaluate current evidence on essential nutrients and dietary patterns, and provide practical guidance for achieving nutritional adequacy during this vital period.

2. Importance of fruits in pregnancy

Adequate fruit consumption during pregnancy plays a critical role in supporting optimal maternal health and fetal development. Fruits are rich sources of essential micronutrients, including vitamin C, folate, carotenoids (provitamin A), and various bioactive phytochemicals that contribute to antioxidant defense, immune modulation, and cellular differentiation. Evidence from a large perspective cohort study in Japan demonstrated that higher maternal fruit intake during early to mid-pregnancy was significantly associated with reduced odds of developmental delays in offspring at 2 years of age (adjusted OR 0.78; 95% CI 0.66–0.92) [13]. Fruits contribute substantially to vitamin C intake, which enhances iron absorption and may reduce the risk of maternal anemia, a known factor influencing adverse neurodevelopmental outcomes [14]. Moreover, fruit-derived folate plays a fundamental role in DNA synthesis, methylation reactions, and neural tube development, thereby supporting early central nervous system formation [15]. The antioxidant properties of fruit constituents further help mitigate oxidative stress, which has been implicated in placental dysfunction and impaired fetal growth [16]. Collectively, current evidence supports the inclusion of adequate fruit intake as part of a balanced maternal diet to promote favorable pregnancy outcomes and early childhood neurodevelopment.

3. Fruits to be avoided during pregnancy

Certain fruits may pose potential risks during pregnancy due to their biochemical constituents, enzymatic activity, or risk of microbial and pesticide contamination. Therefore, cautious selection, proper handling, and moderation in consumption are essential to ensure maternal and fetal safety *(Table.1).*

Papaya, particularly unripe or semi-ripe papaya, is one of the most commonly discussed fruits in relation to pregnancy safety. Unripe papaya contains papain, a proteolytic enzyme capable of degrading proteins and influencing prostaglandin activity. Papain has been associated with stimulation of uterine contractions due to its potential uterotonic properties. Additionally, the latex present in raw papaya is rich in bioactive compounds that may mimic the action of prostaglandins and oxytocin, thereby increasing the risk of uterine stimulation. Excessive intake of unripe papaya has been suggested to increase the risk of miscarriage, particularly during early pregnancy when the uterus is highly sensitive to external stimuli. For this reason, consumption of unripe papaya is generally discouraged, especially during the first trimester, although ripe papaya in moderate amounts is considered safe due to lower papain content [17,18].

Pineapple is another fruit that has raised concerns due to the presence of bromelain, a proteolytic enzyme known for its anti-inflammatory and fibrinolytic properties. Bromelain has been hypothesized to soften cervical tissue by breaking down collagen fibers, which could theoretically contribute to cervical ripening and increase the risk of premature labor if consumed in excessive quantities. Although normal dietary intake of pineapple does not typically provide sufficient bromelain to induce significant physiological effects, excessive consumption or intake in concentrated forms may pose theoretical risks. Clinical evidence directly linking pineapple consumption to miscarriage or preterm labor remains limited; however, healthcare professionals often recommend moderation as a precautionary measure during pregnancy [19].

Grapes, particularly due to their resveratrol content, have also been discussed in the context of pregnancy safety.Resveratrol is a polyphenolic compound with antioxidant, anti-inflammatory, and estrogen-like properties. While resveratrol is generally beneficial in non-pregnant populations, its endocrine-modulating effects may influence hormonal balance and placental development during pregnancy. High levels of resveratrol, particularly from supplements rather than natural dietary sources, may interfere with fetal pancreatic development and placental function. Although moderate consumption of grapes as part of a balanced diet is typically considered safe, excessive intake or supplementation with resveratrol-containing products is not recommended due to potential endocrine and developmental concerns [20].

Unwashed berries and stone fruits such as strawberries, cherries, peaches, and similar fruits may pose risks primarily due to microbial and chemical contamination. These fruits can harbor harmful pathogens such as *Listeria monocytogenes* and *Salmonella*, as well as pesticide residues if not properly washed. Infection with Listeria during pregnancy can lead to serious complications, including miscarriage, preterm birth, neonatal infection, and fetal loss. Pregnant women are particularly susceptible to listeriosis due to immunological changes associated with pregnancy. In addition, pesticide exposure has been linked to adverse pregnancy outcomes, including fetal growth restriction and developmental abnormalities. Proper washing under running water, peeling when appropriate, and selecting organically grown produce when available can significantly reduce these risks and ensure safe consumption [21].

Table 1 Fruits to Be Avoided During Pregnancy

Fruit / Category	Key Bioactive Component / Risk Factor	Potential Mechanism	Possible Pregnancy Risk	Clinical Recommendation	References
Unripe / Semi-ripe Papaya	Papain (proteolytic enzyme), latex compounds	Uterotonic activity; stimulation of prostaglandins and oxytocin-like effects	Uterine contractions; increased risk of miscarriage (especially first trimester)	Avoid unripe papaya; ripe papaya in moderate amounts is generally safe	[17,18]
Pineapple	Bromelain (proteolytic enzyme)	Collagen degradation; theoretical cervical softening and ripening	Theoretical risk of premature labor if consumed excessively	Moderate intake acceptable; avoid excessive or concentrated forms	[19]
Grapes (Excessive / Supplements)	Resveratrol (polyphenol)	Endocrine modulation; possible interference with placental and fetal pancreatic development	Potential hormonal imbalance and developmental concerns (mainly with high-dose supplements)	Moderate dietary intake safe; avoid resveratrol supplements	[20]
Unwashed Berries and Stone Fruits (Strawberries, Cherries, Peaches, etc.)	Microbial contamination (Listeria monocytogenes, Salmonella); pesticide residues	Maternal infection; transplacental transmission; toxic exposure	Miscarriage, preterm birth, neonatal infection, fetal growth restriction	Wash thoroughly under running water; peel when possible; prefer safe/organic sources	[21]

4. Teratogenic fruits: myth versus evidence

The concept of “teratogenic fruits” — implying that certain fruits intrinsically cause congenital anomalies — is largely unsupported by robust human epidemiological evidence. Most claims regarding fruit-induced miscarriage or fetal malformation originate from animal studies conducted with pharmacological or supraphysiological doses that do not reflect typical dietary exposure levels in humans [22]. Extrapolation of such findings to routine maternal nutrition is scientifically inappropriate without dose–response validation in clinical settings. Rather than intrinsic teratogenicity, potential risks associated with fruit consumption during pregnancy are more plausibly linked to extrinsic factors such as microbial contamination, mycotoxins, or pesticide residues. Therefore, it is more accurate to evaluate safety concerns within the framework of food hygiene, environmental exposure, and overall dietary patterns rather than attributing congenital risk directly to the fruit itself.

Qualitative evidence from community-based research further supports the predominance of sociocultural beliefs rather than biomedical causation in shaping perceptions of “harmful” fruits during pregnancy. A recent study conducted among antenatal women in Puducherry, India, demonstrated widespread avoidance of fruits such as papaya, pineapple, mango, and jackfruit due to their classification as “heat-producing” foods believed to induce miscarriage or fetal abnormalities [23]. Similarly, fruits categorized as “cold” (e.g., banana, guava, grapes, and jamun) were avoided due to fears of infection or adverse effects on fetal complexion. Importantly, these beliefs were primarily influenced by family members, particularly mothers-in-law and elder relatives, rather than healthcare professionals. The study concluded that such food taboos may compromise maternal nutritional adequacy and potentially contribute to adverse pregnancy outcomes through micronutrient deficiencies rather than direct teratogenic mechanisms [23]. Collectively, current evidence suggests that misconceptions and cultural narratives, rather than biological teratogenicity, underpin the classification of certain fruits as harmful during pregnancy.

5. Foods to avoid during pregnancy

Pregnancy is a physiologically sensitive period during which maternal dietary intake plays a critical role in ensuring optimal fetal growth and development. Certain foods pose increased risks due to the presence of pathogenic microorganisms, toxic substances, or bioactive compounds that may adversely affect pregnancy outcomes. Therefore, avoidance or careful consumption of specific high-risk foods is recommended to prevent maternal infections, teratogenic effects, and impaired fetal development (***Table. 2)***.

Raw or undercooked meats, eggs, and fish are significant sources of foodborne pathogens that may lead to serious maternal and fetal complications. These foods may harbor microorganisms such as *Toxoplasma gondii*, *Salmonella*, and *Listeria monocytogenes*, which are capable of crossing the placental barrier and causing intrauterine infection. Maternal toxoplasmosis, for example, can result in congenital toxoplasmosis, leading to neurological impairment, visual defects, or fetal loss. Similarly, infection with *Listeria monocytogenes* is associated with miscarriage, preterm labor, stillbirth, and neonatal sepsis. Pregnant women are particularly vulnerable due to pregnancy-induced immunological adaptations, which reduce resistance to intracellular pathogens. Proper cooking of meats, eggs, and seafood to safe internal temperatures is therefore essential to eliminate microbial contamination and minimize infection risk [24].

Table 2 Foods to Avoid During Pregnancy

Food Category	Specific Examples	Primary Risk Factor	Mechanism of Harm	Potential Maternal and Fetal Complications	Recommendation	References
Raw or Undercooked Meat, Eggs, and Fish	Raw meat, undercooked poultry, raw eggs, sushi, raw seafood	*Toxoplasma gondii*, *Salmonella*, *Listeria monocytogenes*	Transplacental infection; intracellular pathogen invasion; systemic maternal infection	Congenital toxoplasmosis, miscarriage, preterm labor, stillbirth, neonatal sepsis, neurological impairment	Cook thoroughly to safe internal temperatures; avoid raw or undercooked animal products	[24]
Unpasteurized Dairy Products	Raw milk, Brie, Camembert, blue cheese, other soft cheeses made from unpasteurized milk	*Listeria monocytogenes*	Psychrotrophic bacterial growth even under refrigeration; transplacental infection	Spontaneous abortion, neonatal meningitis, systemic neonatal infection, preterm delivery	Consume only pasteurized milk and dairy products	[25]
High-Mercury Fish	Shark, swordfish, king mackerel	Methylmercury	Placental transfer and accumulation in fetal CNS; neurotoxicity	Impaired neurodevelopment, reduced IQ, cognitive deficits, behavioral abnormalities	Avoid high-mercury fish; choose low-mercury alternatives	[26]
Excessive Caffeine Intake	Coffee, energy drinks, cola, strong tea	Caffeine	Crosses placenta; reduced uteroplacental blood flow; immature fetal metabolism	Miscarriage, intrauterine growth restriction, low birth weight	Limit intake to <200 mg/day	[27]

Unpasteurized dairy products, including soft cheeses such as Brie, Camembert, and blue cheese, represent another important dietary risk during pregnancy. These products may contain *Listeria monocytogenes*, a psychrotrophic bacterium capable of surviving and proliferating even under refrigeration conditions. Listeriosis during pregnancy can lead to severe complications, including spontaneous abortion, preterm delivery, neonatal meningitis, and systemic infection. Because pasteurization effectively eliminates pathogenic microorganisms, consumption of only pasteurized milk and dairy products is strongly recommended during pregnancy to ensure food safety and prevent adverse pregnancy outcomes [25].

Certain fish species with high mercury content, such as shark, swordfish, and king mackerel, should also be avoided due to their potential neurotoxic effects on the developing fetus. Mercury, particularly in its organic form methylmercury, readily crosses the placental barrier and accumulates in fetal tissues, including the central nervous system. Prenatal exposure to elevated mercury levels has been associated with impaired cognitive function, delayed neurodevelopment, reduced IQ, and behavioral abnormalities in children. The developing fetal brain is especially sensitive to mercury toxicity, making it essential to limit exposure by avoiding high-mercury fish while encouraging safer alternatives with lower mercury content [26].

Excessive caffeine intake during pregnancy has also been associated with adverse reproductive outcomes. Caffeine readily crosses the placenta, and the fetus has limited ability to metabolize it due to immature hepatic enzyme systems. High maternal caffeine consumption has been linked to increased risk of miscarriage, intrauterine growth restriction, and low birth weight. Caffeine may also reduce uteroplacental blood flow and interfere with fetal oxygenation and nutrient delivery. Current evidence suggests that limiting caffeine intake to less than 200 mg per day is a prudent measure to minimize potential risks while maintaining maternal safety [27].

6. Deficiency mechanisms related to fruit avoidance

Avoidance of nutrient-rich fruits during pregnancy without appropriate dietary substitution may result in significant micronutrient deficiencies that can adversely affect both maternal health and fetal development. Fruits serve as essential sources of vitamins, minerals, antioxidants, and bioactive compounds required for physiological adaptation during pregnancy. Restrictive dietary practices, particularly those influenced by cultural beliefs or misconceptions regarding fruit safety, may lead to inadequate intake of critical nutrients such as vitamin C, folate, and potassium. These deficiencies can impair key biological processes, including hematopoiesis, immune function, antioxidant defense, and fetal organogenesis, thereby increasing the risk of maternal complications and adverse pregnancy outcomes.

Vitamin C deficiency is one of the most common nutritional consequences of inadequate fruit consumption during pregnancy. Vitamin C (ascorbic acid) plays a vital role in collagen synthesis, which is essential for maintaining the structural integrity of connective tissues, blood vessels, and the placenta. It also enhances the absorption of non-heme iron by reducing ferric iron to its more absorbable ferrous form, thereby helping to prevent iron deficiency anemia. Inadequate vitamin C intake may result in impaired wound healing, increased oxidative stress, weakened immune function, and increased susceptibility to maternal anemia. Fruits such as oranges, guava, kiwi, and strawberries are major dietary sources of vitamin C, and their avoidance without suitable alternatives may compromise maternal nutritional status and fetal growth [28].

Folate insufficiency represents another critical nutritional concern associated with reduced consumption of folate-rich fruits. Folate is essential for DNA synthesis, cellular division, and methylation reactions, which are particularly important during periods of rapid fetal growth and neural development. Insufficient folate intake during early pregnancy is strongly associated with neural tube defects, including spina bifida and anencephaly. Fruits such as oranges, papaya (when fully ripened and consumed safely), and avocados contribute significantly to daily folate intake. Inadequate consumption of these foods, particularly during the periconceptional period, may impair proper neural tube closure and increase the risk of congenital abnormalities [29].

Potassium imbalance may also occur when potassium-rich fruits such as bananas, apricots, and citrus fruits are avoided. Potassium plays a crucial role in maintaining fluid and electrolyte balance, regulating nerve impulse transmission, and supporting normal muscle function. During pregnancy, adequate potassium intake is essential for maintaining cardiovascular stability and preventing complications such as hypertension and muscle cramps. Reduced potassium intake may contribute to electrolyte imbalance, increased blood pressure, fatigue, and neuromuscular dysfunction. Furthermore, potassium is important for maintaining cellular homeostasis and supporting fetal tissue development, making adequate intake essential throughout pregnancy [30].

At the physiological level, inadequate fruit consumption may disrupt several important biological mechanisms. Reduced intake of antioxidant-rich fruits diminishes the body's ability to neutralize reactive oxygen species, resulting in increased oxidative stress, which has been implicated in complications such as preeclampsia and intrauterine growth restriction. Additionally, insufficient availability of essential micronutrients may impair neurotransmitter synthesis, affecting fetal brain development and maternal neurological function. Deficiencies in vitamin C and folate can also compromise hematopoiesis, leading to anemia and reduced oxygen-carrying capacity, thereby affecting both maternal health and fetal oxygenation. These mechanisms highlight the critical importance of maintaining adequate fruit intake or appropriate nutritional substitution during pregnancy to support optimal maternal and fetal outcomes.

7. Balancing safety and nutrition: clinical recommendations

Maintaining an optimal balance between food safety and adequate nutritional intake is essential during pregnancy to support maternal health and ensure proper fetal growth and development. Clinical guidelines emphasize that pregnant individuals should not unnecessarily restrict nutrient-rich foods, particularly fruits, unless there is clear scientific evidence of harm. Fruits provide essential micronutrients such as vitamin C, folate, potassium, dietary fiber, and antioxidants, which play critical roles in immune function, hematopoiesis, placental development, and fetal organogenesis. Healthcare providers should counsel pregnant women to focus on safe handling practices, including thorough washing, peeling when appropriate, and consuming fresh, hygienically prepared fruits, rather than avoiding them altogether due to unverified teratogenic concerns. Evidence suggests that adequate fruit intake during pregnancy is associated with improved birth outcomes, including healthy birth weight, reduced risk of preterm birth, and enhanced fetal neurodevelopment [31].

Clinical recommendations also emphasize moderation and informed dietary selection rather than complete elimination of specific foods. For example, fruits traditionally considered "unsafe," such as papaya and pineapple, can be safely consumed when ripe and eaten in moderate quantities, as the concentration of biologically active enzymes decreases during ripening and typical dietary intake does not reach harmful levels. Furthermore, international health organizations recommend consuming a diverse range of fruits and vegetables daily to ensure sufficient intake of essential micronutrients and phytochemicals. Pregnant women should also be advised to avoid contaminated or improperly stored fruits, as foodborne infections pose a greater risk than the fruit itself. Proper nutritional counseling by healthcare professionals is crucial to dispel myths, prevent unnecessary dietary restrictions, and ensure balanced nutrition throughout pregnancy [32]. From a clinical perspective, individualized nutritional counseling is particularly important for women with high-risk pregnancies, pre-existing medical conditions, or nutritional deficiencies. Healthcare providers should assess dietary patterns, identify potential deficiencies, and recommend appropriate dietary modifications or supplementation when necessary. Public health strategies should also focus on educating pregnant women and their families about evidence-based dietary practices, as sociocultural beliefs and misinformation often influence food choices. Promoting safe, balanced, and nutrient-rich dietary habits can help prevent micronutrient deficiencies, support placental function, reduce oxidative stress, and improve both short-term and long-term maternal and fetal health outcomes [32].

8. Conclusion

Maternal nutrition plays a fundamental role in ensuring optimal pregnancy outcomes and supporting long-term health for both the mother and offspring. Fruits represent an essential component of a balanced prenatal diet due to their rich content of vitamins, minerals, antioxidants, and bioactive compounds that contribute to fetal growth, placental function, and maternal physiological adaptation. Current scientific evidence indicates that most fruits are safe and beneficial during pregnancy when consumed in appropriate quantities and prepared hygienically. Concerns regarding specific fruits, such as unripe papaya and pineapple, are primarily based on theoretical mechanisms or findings from high-dose experimental studies rather than typical dietary exposure. Importantly, the concept of inherently teratogenic fruits is not supported by robust human clinical evidence. Instead, potential risks are more closely associated with factors such as microbial contamination, improper handling, or excessive consumption of bioactive compounds in non-dietary forms. Therefore, evidence-based dietary guidance should focus on safe consumption practices rather than unnecessary restriction of nutrient-rich foods. Conversely, inappropriate avoidance of fruits due to misconceptions or cultural beliefs may result in significant micronutrient deficiencies, including inadequate intake of vitamin C, folate, and potassium, which are critical for hematopoiesis, neural development, immune function, and maintenance of maternal physiological stability. Such deficiencies may increase the risk of adverse outcomes, including anemia, impaired fetal neurodevelopment, and pregnancy-related complications. Clinical recommendations emphasize the importance of balanced dietary patterns that include a diverse variety of fruits, along with proper washing, safe handling, and moderation in consumption. Healthcare providers play a crucial role in dispelling myths, providing individualized nutritional counseling, and promoting evidence-based dietary practices. Ultimately, ensuring adequate and safe fruit consumption during pregnancy represents a practical and effective strategy to support maternal well-being, optimize fetal development, and contribute to favorable short- and long-term health outcomes.

Compliance with ethical standards

This article is a review based exclusively on previously published studies and publicly available data. No new studies involving human participants or animals were performed by the authors. Therefore, ethical approval and informed consent were not required for this work

Disclosure of conflict of interest

There is no conflict of interest to disclose.

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