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Preparation of Nutritious Ready-to-Drink Fruit and Vegetable Juice for Pregnant Women (4-6 months).

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Highlights

- **Three novel ready-to-drink juice formulations were developed specifically for pregnant women during the 4-6 months of pregnancy**
- **The juices provided high energy levels (58.8–101.4 kcal/100 ml) from balanced carbohydrates and healthy fats**
- **Selected formulations supplied up to twice the recommended daily intake of iron and nearly 50% of zinc requirements**
- **Quality parameters (pH, acidity, and total soluble solids) met acceptable standards for fresh natural juice**

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ABSTRACT

Many pregnant women suffer from disorders during the primary period of pregnancy, which strongly influence the health of mothers and their embryos. This research aimed to prepare and estimate the chemical components of healthy and nutritious ready-to-drink juice prepared from fresh and dried fruits and vegetables known for their health benefits for pregnant women, such as avocado, banana, strawberry, raisins, dried figs, mint, green arugula and other natural ingredients. Three juice formulas were prepared with different natural ingredients, and the chemical composition was estimated in terms of proximate analysis, quality characteristics, mineral content and energy content. Importantly, the percentage of carbohydrates in the samples ranged between 4.34 ±0.010 and 11.89±0.010. The results of the quality analysis indicated that the juice samples were characterized by moderate acidity (1.05±0.020, 4.34±0.00) and that the total soluble solids were within the limits stipulated for natural juices (12.50±0.200, 16.50±0.200). The energy content results demonstrated the high energy content of the formulas, which ranged between 58.84±0.14 and 101±0.26 kcal/100 ml. Mineral analysis revealed that the juice samples were rich in iron, zinc and copper, with values of 50.92±0.0, 5.21±0.428, and 2.21±0.013, respectively. This study confirmed that juice formulas provide a high energy content; important minerals such as iron and zinc; and an excellent percentage of fluids. The study recommended including this type of juice in pregnant women's diets.

1. Introduction

Pregnant women are exposed to numerous physiological changes to support the ordinary and healthy development of the embryo, as well as to prepare the mother and child for birth (Soma-Pillay *et al*., 2016). These changes include: increases in weight, hormone levels (Marsh *et al.,* 2023) and blood content, and changes in the digestive system, including nausea, vomiting, gastroesophageal reflux, and constipation, during the first three months of pregnancy (Soma-Pillay *et al.,* 2016). The wholesome needs of pregnant women increase these changes and guarantee the ordinary advancement of the embryo. An adjusted caloric intake of micronutrients (vitamins, minerals, and omega-3 acids) is a supreme need for numerous cellular and metabolic functions, such as cell division and separation, hemoglobin generation, and oxygen transport. (Jouanne *et al.,* 2021). A sound and changed caloric-count are critical throughout life, especially during pregnancy. When mothers eat less, they must have adequate vitality and supplements to meet the mother's normal requirements, as well as the desire of the developing embryo, and empower the mother to lay down the supplements required for fetal advancement as well as for lactation (Williamson, 2006). The pregnancy and postpartum periods are basic periods in which wholesome admissions are necessary for maternal and child wellbeing, particularly a shortage of fundamental supplements, which is related to negative wellbeing resulting from both the mother and the child (Aparicio *et al.,* 2020). Sustenance plays a crucial role in this formative period, and since it could be a determinant of the lifetime hazard of the malady, pregnant women ought to eat way better, which will be accomplished by basing caloric counts on an assortment of nutrient dense, entire nourishments, including natural products such as vegetables, nutritious fruits, entirety grains, and sound fats with omega-3 greasy acids that incorporate nuts and seeds, and angles (Marshall *et al.,* 2022). Pregnant women should focus on reducing quality and be empowered to select nutrient-rich nourishments tall in imperative vitamins and minerals (Seymour *et al.,* 2019).

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The method for selecting ingredients in each new juice formulation in this study relies on fresh and dried vegetables and fruits, which are characterized by their nutrient content that pregnant women need during these important months of pregnancy. Red beetroot (*Chenopodiaceae family*), is a good source of bioactive ingredients such as betalains, antioxidants, polyphenols, B-vitamins, minerals, carotenoids, flavonoids and vitamin C (Chawla *et al.,* 2016). Many recent studies have indicated the health benefits of red beetroot juice for pregnant women, especially for treating anemia and iron deficiency, in addition to its content of bioactive compounds (Istiqomah & Fauzi, 2022; Khairiah & Butar-Butar, 2022; Fadlilah *et al.,* 2023). For pregnant women, avocado is a good source of important nutrients for mothers and fetuses, as avocado contains folic acid, which is important for protecting mothers from anemia, and is also important for building the nervous system and spinal cord of fetuses. It also contains calcium, which is involved in the formation of bones for the fetus, as it contains many vitamins that are critical for the health of mothers and embryos (Nursila. 2023). Honey has many biological, pharmacological, antioxidant, antimicrobial and anti- inflammatory activities (Hossain *et al.,* 2022). Honey also contains a high percentage of vitamins, namely, B6, thiamine (Brar *et al.,* 2023). Strawberry (*Fragaria xananassa*) is rich in antioxidants, which have beneficial effects on heart health, and eating strawberries provides protection against heart disease, blood vessel damage and diabetes. Strawberries are an excellent source of vitamin C, as a cup of strawberries contains vitamin C equivalent to the content of a cup of fresh orange juice (Hernandez-Martinz *et al,* 2023). Strawberries contain active biochemical compounds such as anthocyanins, vitamins C and A, and minerals. One piece of a strawberry contains 60 grams of vitamins (Ibrahim *et al.,* 2023). Raisins are rich in fiber, phytochemical and phenolic compounds. Despite the presence of 60% sugar, a few raisins have detailed health-promoting properties (Olmo-Cunillera *et al.,* 2019). Figs (dried or fresh) are an essential source of minerals, such as iron, calcium, potassium, vitamins (thiamin and riboflavin), fibers and cancer preventive agents, and fig fruits are free of fat, cholesterol and sodium and have been used in the diet since ancient times because of the belief that they prolong life (Arvaniti *et al.,* 2019; Demirezen *et al.,* 2019; Viuda-Martos et al., 2015). A recent study revealed the health benefits of green arugula, which include helping individuals lose weight; resisting infections; removing toxins; improving vision, skin and bone health; and being beneficial for the health of pregnant women, in addition to being rich in cancer-fighting antioxidants (Sheelavathi, 2023). Bananas are a rich source of energy compared to other fruits, and are more easily digested (AL-Dairt *et al.,* 2023). Bananas contain sugars, vitamins B6 and C, potassium, fiber, phosphorus, protein, fats, iron and folic acid; therefore, they are among the most important fruits for pregnant women, especially with respect to increasing blood levels and providing energy needs (Anhwange, 2008). Kiwifruit cause clogging, and upper gastrointestinal (GI) side effects such as stomach torment, heartburn, and reflux are reduced. Kiwifruit plants contain many nutrients, the most important of which include vitamins C, E, and K; folate; potassium; and a good source of antioxidants and phytonutrients (AL-Siddique et al., 2021; Dawivedi *et al.,* 2021). Date palm sap, known locally in Libya (*laqmi*), is a sap that is traditionally collected by making a cut in the stem of the palm tree at the growing top. It is consumed fresh, especially in the summer (Makhlouf-Gafsi *et al.,* 2015). Date sap juice is a good source of antioxidants and has antimicrobial effects (Makhlouf-Gafsi *et al.,* 2016). Many studies have shown that eating apples is good for heart health and can help prevent chronic diseases (Vallee *et al.,* 2022). Mint is a plant that has been used for medicine for a very long time. It is part of the *Lamiaceae* family. Peppermint oil is widely used to treat many diseases, such as cough, bronchitis, and digestive disorders, vomiting, loss of appetite, and morning sickness (Best, 2022 Yassin *et al.,* 2020). Mint has a soothing and relaxing effect on the muscles and walls of the stomach, which reduces nausea and vomiting, and it is used as an inexpensive treatment with no side effects to improve nausea in cancer patients (Haddadi *et al.,* 2017). Mint is also used to reduce nausea in pregnant women (Abdol Hosseini *et al,* 2017). This research aimed to prepare nutritious juice from fresh and dried fruits and vegetables to meet the needs of pregnant women from the fourth to sixth months of pregnancy.

2. Materials and methods

2.1 Purchases of raw materials

Juice ingredients such as beetroot, fresh arugula, honey, avocado, strawberry, raisin, dried figs, banana, kiwi, green mint, lemon, apple, and date palm sap were purchased from local markets in Zuwara and Aljemail/ west of Libya.

2.2 Preparation of juice samples

In this study, the experimental analytical method was used. Three formulas of juice with nutrient ingredients were prepared. All the ingredients used in the formulation of each juice formula were carefully selected for their good taste and high nutritional and health value.

The vegetables and fruits used in preparing juice formulas were washed well with running water, peeled and cut (Fig. 1). The required proportions for each juice formula were then weighed. The first formula was prepared from (6.68%) beetroot, (2.8%) avocado fruit, (5.68%) honey, (17.07%) strawberry, (5.68%) black raisins, (5.68%) dried figs, (0.56%) green arugula, and (56.91%) water (Fig. 2). The second formula was prepared from (7.01%) beetroot, (8.77%) bananas, (14.05%) kiwi fruit, and (70.17%) date palm sap (Fig. 3). The third formula was prepared from (4.59%) beetroot, (18.38%) apple, (1.18%) lemon juice, (11.15%) banana, (5.59%) honey, (4.59%) black raisins, (4.59%) dried figs, (1.08%) fresh mint and (48.91%) water (Fig. 4). All the prepared ingredients for each formula were mixed in an electric blender, filtered, placed in sterile bottles, closed and stored directly in the refrigerator at 4 °C.

Fig. 1. Preparation steps for the juice formulas

Fig. 2. **Formula (1)**

Fig. 3. **Formula (2)**

Fig. 4. Formula (3)

2.3 Chemical analysis

Juice formulas were chemically analyzed according to the official methods of analysis described by the Association of Official Analytical Chemists (AOAC 2005). The Total Soluble Solids **(T.S.S.)** were determined via a refractometer, which measures the rate of refraction of the substance**. The Titrable acidity** was determined via the titration method using 0.1 N (NaOH) and the phenolphthalein indicator, and the acidity was described as a percentage of citric acid**. The pH** was determined via a multiparameter handheld instrument (Lovibond/ SensoDirect 150), (Tinometer/Thailand). **Moisture:** The moisture content was determined by drying in an oven at 135°C for 2 hours. **Ash:** is the inorganic buildup after food matter burns during nourishment at temperatures ranging from 500-600°C. The ash content of the juice formulations was determined via a muffle furnace at 550°C for 6 hrs. **Protein:** The protein content was determined via the Kjeldahl method and calculated by multiplying the amount of nitrogen by 6.25.

2.4 Determination of minerals

The mineral contents (Fe, Cu, P, K, and Zn) of the juices were determined via the atomic absorption spectrophotometric method described in (Benton and Vernon, 1990). In the Teflon capsules, 0.5 g of juice sample and 8 mL of concentrated nitric acid (97%) were present. After sealing, the capsules were placed in an oven at 105°C for 1 h and then cooled. After cooling, the capsules were put into mineralizing bombs, which were then well sealed and placed on a hot plate (130°C) for 2 h. After 12 h of cooling, the mineralization mixture was collected in 50 mL volumetric flasks, and the volume was adjusted to the mark with double distilled water. The device was measured by directly drawing in the minerals from the stock solution. The contents are expressed in mg/100 g dry matter.

2.5 Energy content

The energy content was determined via a bomb calorimeter (GDY/1A+)/Chongqing/China, by measuring the heat produced by completely burnt samples of a given weight under considerable pressure.

2.6 Statistical analysis:

The obtained results were subjected to statistical analysis via the SPSS program (version 21), and the least significant difference (LSD) test was applied to calculate the value of significant differences at the level of significance ($P \leq 0.05$). The results of the statistical analysis are presented as the means ±SDs.

3. Results and discussion

3.1 Proximate analysis:

Proximate analysis is a basic procedure used to evaluate the quality of food items. This process yields important data regarding essential constituents, including moisture content, ash (minerals), protein, fat, carbohydrates, and fiber (Ullah *et al.,* 2023). Table 1 shows the results of the proximate analysis of the juice formulas, where it is clear that there are significant differences between the formulas in all the chemical characteristics tested; all p-values are less than 0.05. The first formula was characterized by its high contents of ash (mineral elements), and fats (7.93±0.03, 8.95±0.020%) because it contained avocado fruit, whereas formulas 2 and 3 were characterized by high percentages of carbohydrates (11.89±0.010, 11.84±0.020%) and lower percentages of ash and fats (3.56±0.010, 2.40±0.010 and 1.04±0.020, 2.70±0.020%), respectively. All the formulas contained a low percentage of protein (0.48±0.020, 0.85±0.010%), as fruits and vegetables were poor in protein. In a similar experimental design to prepare juice from papaya, pineapple, and beets and use it to treat anemia, the chemical components of the prepared juice were similar to those found in the present study. The ratios of protein, fat, ash, and energy are 0.51-1.24, 12-0.26, 0.14-0.22 and 89-34%, respectively (Mananga *et al.,* 2023). The juice formulas in this study contained excellent percentages of water, in terms of moisture content (MC%), as most pregnant women suffer from dehydration after the first period of pregnancy due to digestive system disorders such as nausea and vomiting. Because vegetables and fruits are poor in fat, adding avocado to sample 2 effectively increased the percentage of healthy fats in the juice, which is one of the most important needs of pregnant women (RDA 3-11 g/day). The results shown in the table also indicated that the prepared juice formulas contained good proportions of carbohydrates, which are considered the most important source of energy for pregnant women. Many studies indicate that pregnant women need an additional 300 calories per day during pregnancy (Jumaeva *et al.,* 2020).

3.2 Quality characteristics:

All foodstuffs contain dissolved solids such as sugars, organic acids, and salts. Estimating these materials is highly important because they express the distinctive characteristics that determine

the quality of food. Natural juices are highly perishable products because they contain high levels of sugars and nutrients that encourage the growth of spoilage microbes. Natural juices are distinguished because they contain many organic acids, such as ascorbic, citric, malic, and tartaric acids. These acids help enhance the body's ability to absorb minerals, such as ascorbic acid, which helps in the absorption of iron, and citric acid, which facilitates the absorption of calcium (Brima & Abbas, 2014). The data presented in Table 2 illustrate the quality characteristics of the juice formulas. The juice formulas were characterized by moderate levels of acidity, ranging from 4.43±0.00 to 1.05±0.02. Measuring the pH is highly important, as any deviation in pH has a direct impact on food spoilage and product stability. The results presented in the same table show that the pH values of the prepared juice formulas ranged between 3.81±0.010 and 4.19±0.010. These are good values for maintaining the quality of the juice, as the juice samples will be consumed fresh and not stored.

3.3 Energy value

Dietary energy (calories) is an indicator of the amount of energy that food provides to the body to perform its vital functions (Roberts and Flaherman, 2022). The results shown in Table 3 indicate that the juice formulas contained excellent percentages of total energy (58.84±0.14, 101.43±0.26), and were distributed among carbohydrates, proteins, and fats. Formula 1 was characterized by the highest percentage of energy from fat because it contains avocado fruit. Protein did not have a significant effect on the energy content. The results also revealed significant differences ($P \geq 0.5$) between samples in terms of the energy content of the energy sources (carbohydrates, proteins and fats) and the total energy. The total energy in formulas 2 and 3 clearly indicated a high carbohydrate percentage. The basal metabolic rate (BMR) of pregnant women essentially increases at the beginning of the fourth month due to numerous physiological changes, such as increased development of the uterus, placenta, baby, blood volume, and mammary glands. As a pregnant woman's weight increases during pregnancy, her energy needs also increase (Tang *et al.,* 2016). Vitality needs to be met amid pregnancy changes in accordance with the pregnant woman's basal metabolic rate (BMR). Studies indicate that a pregnant woman's needs during pregnancy amount to 85,000 additional calories over the course of 40 weeks of pregnancy (Jumaeva *et al.,* 2020); therefore, the pregnant woman must follow a healthy diet that contains a sufficient amount of energy. Protein, vitamins and minerals are needed to meet the developmental needs of mothers and embryos (Tang *et al.,* 2016).

3.4 Mineral content

Minerals are essential nutrients that play a crucial role in several physiological functions necessary for human health. These functions include maintaining fluid balance, facilitating muscle contraction, transmitting nerve signals, forming bones and tissues, and regulating enzyme activity (Razzaque and Wimalawansa, 2025). Table (4) shows the percentages of minerals (iron, copper, phosphorous, potassium and zinc) in the juice samples. As shown, the juice samples are rich in mineral elements that are important for women's health during pregnancy. It is obvious that samples 1 and 3 provide approximately twice the pregnant woman's requirements for iron per day (50.92±0.021, 47.31±.036) (RDA 22-27 mg/day), and half of her need for zinc (5.21±0.428, 3.79±0.009), respectively (RDA 11 mg/day). Notably, the juice samples contained small percentages of potassium and phosphorus. Iron is the main element involved in the production of hemoglobin in the blood and the transport of oxygen, and thus helps increase the blood mass and the growth of the fetus and placenta (WHO, 2016). Zinc is highly important for many vital processes during pregnancy, such as cell division, protein and nucleic acid synthesis, and its deficiency leads to congenital malformations, delayed fetal development, and low birth weight (Shah & Sachdev, 2006).

Table 1. Proximate analysis of juice formulas

Formula	Mean ± SD				
	Moisture%	Ash%	Protein%	Fat%	Carb. %
1	77.90±0.040	7.93±0.030	0.85±0.010	8.95±0.020	4.37±0.010
2	83.03±0.020	3.56±0.010	0.48±0.020	1.04±0.020	11.89±0.010
3	82.33±0.020	2.40±0.010	0.64±0.020	2.79±0.000	11.84±0.020
P-value	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Comment	**S**	**S**	**S**	**S**	**S**

ANOVA (F test) was used at the 0.05 significance level, S=significantly different, NS= not significantly different

Table 2. Quality characteristics of the juice formulas

Formula	Mean ± SD		
	pH	Acidity (as citric acid)	TSS
1	3.81±0.010	1.05±0.020	12.50±0.200
2	4.19±0.010	3.53±0.010	16.00±0.000
3	4.01±0.010	4.34±0.000	16.20±0.200
P-value	**0.000**	**0.000**	**0.000**
Comment	**S**	**S**	**S**

ANOVA (F test) was used at the 0.05 significance level, S = significantly different, NS = not significantly different

Table 3. Energy values of juice formulas kcal/100 ml

Formula	Mean ± SD			
	Carbohydrate	Protein	Fat	Total energy
1	17.48±0.04	3.4±0.04	80.55±0.18	101.43±0.26
2	47.56±0.04	1.92±0.08	9.36±0.18	58.84±0.14
3	47.36±0.08	2.56±0.08	25.11±0.0	75.03±0.00
P value	**0.000**	**0.000**	**0.000**	**0.000**
Comment	**S**	**S**	**S**	**S**

ANOVA (F test) was used at the 0. 05 significance level, S= significantly different, NS = not significantly different

Table 4. Mineral content (mg/100 ml)

Formula	Mean ± SD				
	Fe	Cu	P	k	Zn
1	50.92±0.021	1.66±0.017	0.08±0.02	0.12±0.01	5.21±0.428
2	26.34±0.129	2.21±0.013	0.27±0.02	0.14±0.02	2.44±0.005
3	47.31±0.036	1.09±0.003	0.01±0.01	0.09±0.01	3.79±0.009
P-value	**0.000**	**0.000**	**0.000**	**0.014**	**0.000**
Comment	**S**	**S**	**S**	**S**	**S**

ANOVA (F test) was used at the 0.05 significance level, S= significantly different, NS =not different

4. Conclusion

In the present study, three formulas of natural vegetables and fresh and dried fruit juices were prepared. The ingredients used in this study were selected on the basis of the nutritional needs of pregnant women during the specified period of pregnancy (4-6 months), and the proportions required to prepare the juice formulas were determined. The chemical and quality characteristics were estimated, and the energy percentages of the prepared juice samples were determined. The results proved that the juice samples contained high percentages of iron and zinc and good proportions of energy and macro- and micronutrients (carbohydrates and healthy fat, copper, phosphorus, and potassium).

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