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COMPARATIVE ANALYSIS OF ORGANIC, CONVENTIONAL, AND CONTROL CULTIVATION PRACTICES ON THE NUTRITIONAL COMPOSITION OF CHILI FRUIT *(CAPSICUM* SPP.*)* IN KHARIF AND RABI SEASONS IN JAIPUR DISTRICT, RAJASTHAN

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This study provides a detailed comparative analysis of the nutritional and chemical composition of chili fruits (*Capsicum* spp.) grown under organic, conventional, and control farming practices in Jaipur District, Rajasthan, during the Kharif and Rabi seasons of 2020. The research aims to evaluate how different cultivation methods affect the macro and micronutrient content, as well as the levels of vitamins and bioactive compounds, in chili fruits. A wide range of parameters were assessed, including moisture, ash, fat, protein, carbohydrates, crude fiber, total soluble solids, phosphorus, zinc, potassium, sodium, magnesium, calcium, iron, thiamine, riboflavin, niacin, vitamin C, carotene, and bioactive compounds such as capsaicin and dihydrocapsaicin. The findings reveal that organic farming produced chili fruits with higher protein (15.50 g/100g), fat (8.20 g/100g), and crude fiber (2.90 g/100g) compared to conventional and control farming practices. Organic fruits also demonstrated superior concentrations of key minerals, such as potassium (125 mg/100g), sodium (75 mg/100g), and magnesium (20 mg/100g), which are vital for human health. Additionally, organically grown chilies were richer in vitamin C (66.00 mg/100g) and carotene (0.35 mcg), essential for their antioxidant properties, and bioactive compounds like capsaicin plus dihydrocapsaicin (2.6 mg/100g), known for their therapeutic effects including anti-inflammatory and pain-relief benefits. These results indicate that organic farming not only enhances the nutrient density of chili fruits but also boosts their health-promoting properties. This study highlights the potential of organic chili cultivation to improve dietary intake, particularly in regions facing nutritional deficiencies, and underscores the benefits of organic farming practices over conventional methods in promoting sustainable agriculture.

Keywords: Bioactive compounds, Capsaicin, Chemical analysis, Dihydrocapsaicin, Kharif, Micronutrients, Nutritional composition, Rabi.

Introduction

Chili (*Capsicum* spp.) is an important horticultural crop widely grown in India, particularly in regions like Rajasthan, where it is valued for its culinary and medicinal properties[1]. Chili peppers are known for their rich content of vitamins, minerals, and bioactive compounds, especially capsaicin, which is responsible for their pungency and health benefits such as pain relief, anti-inflammatory effects, and improved digestion[2]. Given the growing global demand for nutrient-dense foods, understanding how different agricultural practices impact the nutritional quality of chili fruits is crucial for optimizing both crop yield and public health outcomes[3]. In Rajasthan, agriculture is primarily rain-fed, and both the Kharif (monsoon) and Rabi (winter) seasons provide opportunities for cultivating crops such as chili[4]. Organic farming, which relies on natural inputs such as compost and biopesticides, is gaining popularity due to its perceived benefits for both human health and environmental sustainability[5]. Conventional farming, on the other hand, uses synthetic fertilizers and chemical pesticides to maximize yield, often at the expense of nutrient density and soil health[6]. Control farming, which involves minimal external inputs, offers a baseline to evaluate the effectiveness of both organic and conventional methods[7].

Organic farming has been increasingly recognized for its potential to enhance the nutrient density of crops while promoting environmental sustainability. According to a study by Benbrook et al.[6], organically grown fruits and vegetables tend to have higher levels of antioxidants, vitamins, and minerals compared to their conventionally grown counterparts. This is largely due to the use of natural fertilizers, which improve soil health and promote better nutrient uptake by plants. Organic farming also tends to reduce the use of synthetic chemicals, which can degrade soil quality over time and negatively impact plant nutrition[5].

Several studies have highlighted the specific advantages of organic cultivation for chili fruits. For instance, Sharma et al.[3] found that organically grown chilies exhibited higher levels of capsaicin and vitamin C compared to those grown conventionally. This was attributed to the use of organic inputs that enhance the biological activity of the soil, fostering the growth of beneficial microorganisms that improve nutrient availability. Similarly, Ramesh et al.[8] reported that organic farming resulted in higher concentrations of minerals such as potassium and calcium, which are critical for plant health and fruit quality. Chili peppers are an excellent source of macronutrients, vitamins, and bioactive compounds. Studies have shown that chili fruits are rich in protein, carbohydrates, fiber, and essential fatty acids, making them a valuable component of a balanced diet[1]. Furthermore, chili peppers contain significant amounts of vitamins A, C, and E, as well as carotenoids such as beta-carotene, which are known for their antioxidant properties[9]. The presence of capsaicin, a bioactive compound responsible for the heat of chili peppers, has been extensively studied for its health benefits, including its ability to reduce pain and inflammation[2].

Mineral content is another important factor in the nutritional quality of chili fruits. A study by Pareek et al.[10] demonstrated that chili peppers are a good source of essential minerals like potassium, calcium, magnesium, and iron, which contribute to various physiological functions, including bone health, muscle function, and oxygen transport. The same study indicated that farming practices significantly influence the mineral content of chili fruits, with organic farming yielding higher concentrations of these vital nutrients.

The nutrient content of chili fruits is also influenced by seasonal variations. The Kharif and Rabi seasons, with their differing climatic conditions, can affect the growth and nutrient uptake of chili plants. A study by Gupta et al.[4] found that chilies grown in the Rabi season generally had higher concentrations of bioactive compounds like capsaicin, as cooler temperatures may promote the accumulation of these secondary metabolites. However, the Kharif season, with its abundant rainfall, tends to support better macronutrient composition, including higher protein and carbohydrate content in chili fruits. Understanding these seasonal differences is critical for optimizing chili cultivation practices to maximize both yield and nutritional quality. Organic farming has been shown to adapt well to these seasonal variations, improving both soil health and crop resilience in the face of climatic challenges[7].

This study aims to provide a comparative analysis of the nutritional composition of chili fruits grown under organic, conventional, and control practices during the Kharif and Rabi seasons in Jaipur District, Rajasthan. By evaluating key nutritional parameters such as protein, fat, carbohydrates, fiber, minerals, vitamins, and bioactive compounds like capsaicin, the study seeks to determine which cultivation method offers the best nutritional outcomes.

Material and Methods

Study Area:

The study was conducted in the Jaipur District of Rajasthan, India, an agricultural region known for its emerging interest in organic farming and favorable climatic conditions for chili (*Capsicum* spp.) cultivation. Jaipur's semi-arid climate, with its distinct Kharif (monsoon) and Rabi (winter) seasons, provides an ideal environment for studying the impact of different agricultural practices on crop quality. The Kharif season, which typically spans from June to September, is characterized by higher temperatures and rainfall, while the Rabi season, from October to March, is cooler and drier. These contrasting seasonal conditions allowed for a comprehensive assessment of the effects of organic, conventional, and control farming practices on the nutritional composition of chili fruits. The study was conducted over the course of 2020, covering both agricultural cycles to ensure a thorough analysis of seasonal variations.

Sample Collection and Analysis:

A total of 30 organically grown chili fruit samples were collected from certified organic farms across Jaipur District. These farms were selected based on their adherence to organic farming standards, which were verified by certification bodies recognized by the government. Organic farming practices at these farms included the use of natural fertilizers such as compost, manure, and biopesticides, without the use of synthetic chemicals or genetically modified organisms (GMOs). The organic samples were intended to represent the best practices in sustainable agriculture in the region. For comparison, chili samples were also collected from farms using conventional farming practices, where synthetic fertilizers, pesticides, and other chemical inputs were employed to maximize yield. These conventional farms served as a benchmark to assess the differences in nutrient composition between organic and chemically intensive farming methods. In addition to organic and conventional samples, control samples were collected from farms with minimal intervention. These control farms operated with limited external inputs, relying primarily on the natural fertility of the soil and rain-fed irrigation. This group provided a baseline for evaluating how much the farming inputs (both organic and conventional) influenced the nutrient composition of the chili fruits.

All chili fruits were harvested at peak maturity to ensure consistency across the different farming systems. Harvest timing was determined by evaluating the fruits' color, size, and firmness, ensuring optimal nutritional content at the time of collection. After harvest, the chili fruits were carefully cleaned to remove any dirt, debris, or foreign matter. The fruits were then air-dried in a clean, well-ventilated environment until they reached a stable weight, which ensured that moisture content was minimized and consistent across all samples.Once dried, the chili fruits were ground into a fine powder using a mechanical grinder, ensuring uniform particle size for subsequent analysis. The powder form allowed for easier handling and more accurate measurements in the various nutritional and chemical analyses that followed. Each sample was stored in labelled, airtight containers under controlled conditions to prevent contamination and preserve its integrity until testing. This meticulous sample collection process, carried out over both the Kharif and Rabi seasons, ensured that the study could comprehensively evaluate the impact of different farming practices on the nutritional and chemical composition of chili fruits, while accounting for seasonal variability. The nutritional composition of the chili samples was analyzed using a series of standardized procedures. Each parameter was measured in triplicate to ensure accuracy, and all analyses were conducted following the protocols established by the Bureau of Indian Standards (BIS) and other recognized methods, as described in table 1.

Table 1: Standard Methods for Nutritional and Chemical Analysis of Organically Grown Chilli Samples in Jaipur District, Rajasthan[7,8].

Test Parameter	Unit	Test Method	Description of Standard Methods
Moisture	gm/100gm	IS:1797:1985	Determined using hot air oven drying method at 105°C until constant weight.
Ash	gm/100gm	IS:1797:1985	Sample incinerated at 550°C in a muffle furnace until white ash is obtained.
Fat	gm/100gm	IS:1797:1985	Extracted using Soxhlet apparatus with petroleum ether as solvent.
Protein	gm/100gm	IS:7219:1973	Determined using Kjeldahl method for total nitrogen, converted to protein.
Carbohydrates	gm/100gm	IS:1656:2007	Calculated by difference method: 100 - (Moisture + Ash + Protein + Fat).
Total Soluble Solids	gm/100gm	HLPL/CHEM/EQP/002	Measured using refractometer at a standard temperature.
Phosphorus	mg/100gm	HLPL/CHEM/EQP/003	Analyzed by colorimetric method using spectrophotometer.
Zinc	mg/100gm	HLPL/CHEM/EQP/004	Determined by Atomic Absorption Spectrophotometry (AAS).
Capsaicin + Dihydrocapsaicin	mg/100gm	HLPL/CHEM/EQP/004	Analyzed by High-Performance Liquid Chromatography (HPLC).
Potassium	mg/100gm	HLPL/CHEM/EQP/018	Determined by Flame Photometry.
Sodium	mg/100gm	HLPL/CHEM/EQP/018	Determined by Flame Photometry.
Magnesium	mg/100gm	HLPL/CHEM/EQP/004	Determined by Atomic Absorption Spectrophotometry (AAS).
Copper	mg/100gm	HLPL/CHEM/EQP/004	Determined by Atomic Absorption Spectrophotometry (AAS).
Calcium	mg/100gm	HLPL/CHEM/EQP/004	Determined by Atomic Absorption Spectrophotometry (AAS).
Iron	mg/100gm	HLPL/CHEM/EQP/003	Analyzed by colorimetric method using spectrophotometer.
Thiamine (Vitamin B1)	mg/100gm	HLPL/CHEM/EQP/004	Analyzed by High-Performance Liquid Chromatography (HPLC).
Carotene	mcg	HLPL/CHEM/EQP/004	Analyzed by High-Performance Liquid Chromatography (HPLC).
Riboflavin (Vitamin B2)	mg/100gm	HLPL/CHEM/EQP/004	Analyzed by High-Performance Liquid Chromatography (HPLC).
Niacin (Vitamin B3)	mg/100gm	HLPL/CHEM/EQP/001	Analyzed by High-Performance Liquid Chromatography (HPLC).
Vitamin C	mg/100gm	IS:5838:1970	Determined by titration with 2,6-dichlorophenolindophenol solution.
Crude Fiber	gm/100gm	IS:1797:1985	Determined by acid-base digestion method using standardized procedures.

Results and Discussion

The current study evaluates the macronutrient, micronutrient, and bioactive compound composition of chili fruits (*Capsicum* spp.) grown under organic, conventional, and control farming practices during the Kharif and Rabi seasons. The results are presented across three tables, focusing on the nutritional aspects of these farming systems, and are aligned with findings from previous studies.

Macronutrient Composition:

The analysis of macronutrient composition (Table 2) revealed significant variations between organic, conventional, and control farming practices. Organic chili fruits exhibited the highest moisture content in both Kharif (12.00 g/100g) and Rabi (11.40 g/100g) seasons, while control fruits had the lowest moisture levels. These findings suggest that organic farming practices, which rely on the use of organic matter and compost, enhance soil water-holding capacity, thus supporting higher moisture retention in fruits[6]. Similar trends were observed by Mäder et al.[5], who reported that organic farming systems improve soil structure and microbial activity, resulting in better moisture availability for crops. Ash content, an indicator of the total mineral content in the fruits, was also highest in organically grown fruits, with 8.50 g/100g in Kharif and 8.10 g/100g in Rabi. This superior mineral profile can be attributed to the organic farming system's reliance on natural soil amendments, such as compost and manure, which enrich the soil with essential nutrients and improve nutrient cycling[11]. Fat content was higher in organic fruits compared to conventional and control fruits across both seasons. Organic fruits contained 8.20 g/100g fat in Kharif and 8.10 g/100g in Rabi. Organic farming systems, which promote a balanced and slow nutrient release, likely lead to better lipid accumulation in the fruits[3]. This is particularly important for the sensory attributes and energy content of chili fruits, enhancing their overall nutritional value.

Table 2: Macronutrient Composition of Chili Fruits under Organic, Conventional, and Control Farming Practices during Kharif and Rabi Seasons

S. No	Test Parameters	Unit	Organic		Conventional		Control	
			(Kharif)	(Rabi)	(Kharif)	(Rabi)	(Kharif)	(Rabi)
1	Moisture	gm/100gm	12.00	11.40	11.60	11.00	11.00	10.50
2	Ash	gm/100gm	8.50	8.10	8.10	7.80	7.70	7.40
3	Fat	gm/100gm	8.20	8.10	7.90	7.70	7.40	7.20
4	Protein	gm/100gm	15.50	15.00	14.50	14.00	14.00	13.50
5	Carbohydrates	gm/100gm	56.00	57.50	57.50	59.00	59.00	60.50
6	Crude Fiber	gm/100gm	2.90	2.80	2.80	2.60	2.60	2.40
7	Total Soluble Solids	gm/100gm	0.40	0.30	0.50	0.40	0.60	0.50

Protein content followed a similar trend, with organic fruits exhibiting the highest protein levels at 15.50 g/100g in Kharif and 15.00 g/100g in Rabi, compared to conventional and control fruits. Organic farming, which improves nitrogen availability through organic fertilizers, likely contributes to enhanced protein synthesis. These results align with the findings of Chassy et al.[11], who reported that organic fruits and vegetables generally contain higher protein levels due to improved nutrient availability in organic soils. Carbohydrate content was highest in control fruits, particularly during the Rabi season (60.50 g/100g), while organic fruits had the lowest carbohydrate levels (57.50 g/100g). This suggests that while control fruits may accumulate more carbohydrates, organic fruits provide a more balanced macronutrient profile, offering higher protein and fat content. The lower carbohydrate content in organic fruits can be linked to improved nutrient partitioning, where more nutrients are directed toward protein and fat synthesis. Crude fiber content was highest in organic fruits, with 2.90 g/100g in Kharif and 2.80 g/100g in Rabi. Higher fiber content is beneficial for digestive health and helps in reducing the risk of chronic diseases, such as cardiovascular diseases. Previous studieshave similarly shown that organic farming systems tend to produce crops with higher fiber content due to improved soil management practices that enhance plant health and resilience[12].

Micronutrient Composition:

The micronutrient composition of chili fruits cultivated under organic, conventional, and control farming practices during the Kharif and Rabi seasons is presented in Table 3. The analysis highlights significant variations in the levels of essential minerals, including phosphorus, zinc, potassium, sodium, magnesium, calcium, and iron, across the different farming systems. These differences not only reflect the nutritional quality of the fruits but also the impact of farming practices on mineral content.

Table 3: Micronutrient Composition of Chili Fruits under Organic, Conventional, and Control Farming Practices during Kharif and Rabi Seasons

S. No	Test Parameters	Unit	Organic		Conventional		Control	
			(Kharif)	(Rabi)	(Kharif)	(Rabi)	(Kharif)	(Rabi)
1	Phosphorus	mg/100gm	45.00	42.00	43.00	40.00	41.00	39.00
2	Zinc	mg/100gm	0.12	0.10	0.10	0.09	0.09	0.08
3	Potassium	mg/100gm	125.00	120.00	120.00	115.00	115.00	110.00
4	Sodium	mg/100gm	75.00	70.00	72.00	67.00	68.00	65.00
5	Magnesium	mg/100gm	20.00	19.00	19.00	17.50	18.00	17.00
6	Copper	mg/100gm	ND	ND	ND	ND	ND	ND
7	Calcium	mg/100gm	15.00	14.50	14.50	14.00	14.00	13.50
8.	Iron	mg/100gm	2.00	1.70	1.80	1.60	1.60	1.40

Table 4: Vitamin and Bioactive Compound Content in Chili Fruits under Organic,Conventional, and Control Farming Practices during Kharif and Rabi Seasons.

S. No	Test Parameters	Unit	Organic		Conventional		Control	
			(Kharif)	(Rabi)	(Kharif)	(Rabi)	(Kharif)	(Rabi)
1	Thiamine (Vitamin B1)	mg/100gm	0.10	0.09	0.09	0.08	0.08	0.07
2	Riboflavin (Vitamin B2)	mg/100gm	0.10	0.09	0.09	0.08	0.08	0.07
3	Niacin (Vitamin B3)	mg/100gm	1.30	1.20	1.20	1.10	1.10	1.00
4	Vitamin C (Ascorbic Acid)	mg/100gm	66.00	64.00	63.00	61.00	60.00	58.00
5	Carotene (Provitamin A)	mcg (Microgram)	0.35	0.30	0.30	0.28	0.28	0.25
6	Capsaicin + Dihydrocapsaicin	mg/100gm	2.60	2.50	2.40	2.30	2.20	2.10

Organic chili fruits exhibited the highest phosphorus levels at 45.00 mg/100g during the Kharif season and 42.00 mg/100g in the Rabi season. In comparison, conventional fruits contained 43.00 mg/100g and 40.00 mg/100g, while control fruits had 41.00 mg/100g and 39.00 mg/100g. Phosphorus is a critical macronutrient that plays a vital role in energy transfer, photosynthesis, and root development. The higher phosphorus content in organic fruits suggests that organic farming practices enhance nutrient availability, likely due to the use of organic fertilizers and amendments, which improve soil health and nutrient cycling. This finding is consistent with previous research indicating that organic farming systems promote better phosphorus uptake in crops[5]. The zinc levels in organic chili fruits were recorded at 0.12 mg/100g in Kharif and 0.10 mg/100g in Rabi. In comparison, conventional fruits showed zinc levels of 0.10 mg/100g and 0.09 mg/100g, while control fruits contained 0.09 mg/100g and 0.08 mg/100g. Zinc is an essential micronutrient involved in various physiological processes, including immune function and protein synthesis. The increased zinc content in organic fruits underscores the enhanced micronutrient density associated with organic farming, which often employs practices that improve soil fertility and availability of trace mineral.

Organic chili fruits had the highest potassium content, with 125.00 mg/100g in Kharif and 120.00 mg/100g in Rabi. Conventional fruits had 120.00 mg/100g and 115.00 mg/100g, while control fruits contained 115.00 mg/100g and 110.00 mg/100g. Potassium plays a crucial role in regulating fluid balance, muscle contractions, and nerve function. The elevated potassium levels in organic fruits may result from effective nutrient management practices that enhance potassium uptake. This aligns with findings by Chassy et al.[13], who noted that organic farming practices tend to increase potassium levels in fruits and vegetables. The presence of higher potassium levels in organic chili fruits supports their nutritional quality and potential health benefits for consumers. Sodium levels in organically grown chili fruits were recorded at 75.00 mg/100g in Kharif and 70.00 mg/100g in Rabi. In comparison, conventional fruits had sodium levels of 72.00 mg/100g and 67.00 mg/100g, while control fruits contained 68.00 mg/100g and 65.00 mg/100g. Sodium is important for maintaining fluid balance and nerve function, but excessive intake can lead to health issues such as hypertension. The moderate sodium levels in organic fruits highlight the potential for healthier dietary choices, particularly compared to processed foods that are often high in added sodium.

The magnesium content in organic chili fruits was 20.00 mg/100g in Kharif and 19.00 mg/100g in Rabi, indicating a good level of this essential mineral. Conventional fruits contained 19.00 mg/100g in Kharif and 17.50 mg/100g in Rabi, while control fruits had 18.00 mg/100g and 17.00 mg/100g, respectively. Magnesium is crucial for many biochemical reactions in plants, including those involved in energy production and photosynthesis. The higher magnesium levels in organic fruits can be attributed to the use of organic soil amendments that enhance nutrient availability. For consumers, adequate magnesium intake is vital for muscle function, bone health, and cardiovascular function. The calcium content of organically grown chili fruits was measured at 15.00 mg/100g in Kharif and 14.50 mg/100g in Rabi. In comparison, conventional fruits contained 14.50 mg/100g and 14.00 mg/100g, while control fruits had 14.00 mg/100g and 13.50 mg/100g. Calcium is essential for maintaining cell wall integrity and supporting various metabolic functions in plants. The higher calcium levels in organic fruits reflect the advantages of organic farming practices in improving mineral availability in the soil, which in turn enhances the nutrient content of the crops. The iron content of organically grown chili fruits was recorded at 2.00 mg/100g in Kharif and 1.70 mg/100g in Rabi. Conventional fruits had iron levels of 1.80 mg/100g and 1.60 mg/100g, while control fruits showed 1.60 mg/100g and 1.40 mg/100g. Iron is crucial for the synthesis of haemoglobin and for various enzymatic reactions within the body. The higher iron levels in organic fruits highlight the nutritional benefits of consuming organically grown produce, as iron is essential for preventing anaemia and supporting overall metabolic functions.

Vitamin and Bioactive Compound Composition:

Table 4 presents the vitamin and bioactive compound content in chili fruits cultivated under organic, conventional, and control farming practices during the Kharif and Rabi seasons.

The organically grown chili fruits contained 0.10 mg/100g of thiamine in Kharif and 0.09 mg/100g in Rabi. In comparison, conventional fruits showed thiamine levels of 0.09 mg/100g and 0.08 mg/100g, while control fruits had the lowest levels at 0.08 mg/100g and 0.07 mg/100g, respectively. Thiamine is essential for carbohydrate metabolism and plays a crucial role in energy production. The higher thiamine content in organic chili fruits suggests that organic farming practices enhance the availability of B vitamins, potentially due to improved soil health and nutrient cycling. These findings indicate that consuming organic chili fruits can contribute positively to dietary thiamine intake, essential for maintaining metabolic functions.Riboflavin levels in organic chili fruits were recorded at 0.10 mg/100g in Kharif and 0.09 mg/100g in Rabi. Conventional fruits contained 0.09 mg/100g and 0.08 mg/100g, while control fruits had 0.08 mg/100g and 0.07 mg/100g. Riboflavin is vital for energy production and cellular function, as it is a precursor to coenzymes involved in metabolic pathways. The higher riboflavin content in organic fruits reinforces the potential benefits of organic farming practices in enhancing the nutritional value of crops. This supports findings from previous studies that indicate organically grown crops often have higher vitamin contents, which are critical for maintaining overall health[13].

The organically grown chili fruits exhibited niacin levels of 1.30 mg/100g in Kharif and 1.20 mg/100g in Rabi, surpassing the niacin content in both conventional (1.20 mg/100g and 1.10 mg/100g) and control fruits (1.10 mg/100g and 1.00 mg/100g). Niacin is essential for DNA repair, energy metabolism, and the synthesis of fatty acids and cholesterol. The higher niacin levels in organic fruits indicate that organic farming practices may enhance the bioavailability of B vitamins, likely due to improved soil management and nutrient input strategies. This underscores the importance of organic farming in producing nutrient-dense foods that can help prevent deficiencies in essential vitamins.Vitamin C is a powerful antioxidant known for its role in immune function and collagen synthesis. Organic chili fruits contained significantly higher vitamin C levels, with 66.00 mg/100g in Kharif and 64.00 mg/100g in Rabi, compared to conventional fruits (63.00 mg/100g and 61.00 mg/100g) and control fruits (60.00 mg/100g and 58.00 mg/100g). The enhanced vitamin C content in organic chili fruits may be attributed to the absence of synthetic fertilizers and pesticides, which can reduce plant stress and promote higher antioxidant levels. The higher levels of vitamin C in organic fruits highlight their potential health benefits, particularly in supporting immune health and providing antioxidant protection against oxidative stress.

The carotene content in organic chili fruits was measured at 0.35 mcg in

Kharif and 0.30 mcg in Rabi, higher than the levels found in conventional (0.30 mcg and 0.28 mcg) and control fruits (0.28 mcg and 0.25 mcg). Carotene is a precursor to vitamin A, essential for vision, immune function, and skin health. The increased carotene levels in organic fruits suggest that organic farming conditions, which often involve less environmental stress and improved nutrient availability, promote higher carotenoid accumulation in crops[15]. This finding reinforces the importance of organic farming for producing fruits with enhanced health-promoting compounds.Finally, the content of capsaicin and dihydrocapsaicin, responsible for the pungency of chili, was found to be highest in organic fruits at 2.60 mg/100g in Kharif and 2.50 mg/100g in Rabi, compared to conventional (2.40 mg/100g and 2.30 mg/100g) and control fruits (2.20 mg/100g and 2.10 mg/100g). Capsaicin is not only important for flavour but also possesses numerous health benefits, including anti-inflammatory and analgesic properties. The higher levels of these bioactive compounds in organic chili fruits may be due to the natural growing conditions that foster enhanced phytochemical production. This highlights the dual benefits of organic farming in terms of both flavour enhancement and health benefits.

Conclusion

This study provides a comprehensive comparative analysis of the nutritional composition of chili fruits (*Capsicum spp.*) grown under organic, conventional, and control cultivation practices during the Kharif and Rabi seasons in Jaipur District, Rajasthan. The results highlight the significant impact of different farming practices on the macronutrient, micronutrient, and bioactive compound content of chili fruits, emphasizing the nutritional advantages of organic farming.Organic farming consistently produced chili fruits with superior nutritional profiles compared to conventional and control methods. The moisture, fat, protein, ash, and crude fiber contents were highest in organically grown chili fruits across both seasons. This suggests that organic practices, which rely on compost, natural fertilizers, and biopesticides, foster improved soil health, better nutrient availability, and more balanced nutrient partitioning in crops. The higher protein content in organic chili fruits, particularly during the Kharif season, indicates better nitrogen assimilation, likely due to organic fertilizers that improve soil structure and microbial activity. Furthermore, the increased fat and crude fiber content in organic fruits enhances their nutritional value, contributing to better dietary fiber intake and energy provision.While control fruits exhibited the highest carbohydrate content, especially during the Rabi season, organic fruits presented a more balanced macronutrient profile, offering higher protein and fat levels. This balanced profile is particularly important for consumers seeking nutrient-dense foods that support a healthy diet. Organic fruits also demonstrated improved moisture retention, likely due to enhanced soil water-holding capacity, a critical factor in arid regions like Rajasthan.

In terms of micronutrients, organic farming significantly enhanced the concentrations of essential minerals such as phosphorus, potassium, magnesium, calcium, and iron. These minerals are crucial for various physiological functions, including bone health, nerve function, muscle contraction, and oxygen transport. The higher levels of these micronutrients in organic chili fruits indicate that organic farming practices promote better nutrient cycling and uptake, leading to nutritionally superior crops. The increase in phosphorus and potassium, in particular, underscores the benefits of organic soil amendments, which enhance root development and energy transfer in plants. Zinc, an essential trace element for immune function and protein synthesis, was also found in higher concentrations in organic fruits; further supporting the enhanced micronutrient density associated with organic farming.The study also revealed that organically grown chili fruits had higher levels of vitamins and bioactive compounds, particularly thiamine (Vitamin B1), riboflavin (Vitamin B2), niacin (Vitamin B3), and vitamin C. These vitamins play critical roles in energy metabolism, DNA repair, immune function, and antioxidant protection. The significantly higher vitamin C content in organic chili fruits, known for its role in boosting immunity and protecting against oxidative stress, highlights the health benefits of organic produce. Furthermore, the elevated levels of carotene (provitamin A) in organic fruits enhance their contribution to vision and skin health, while the increased capsaicin content, responsible for the fruit's pungency and various health benefits such as pain relief and anti-inflammatory effects, underscores the enhanced bioactive compound profile in organic chili fruits.Seasonal variations also played a role in nutrient composition, with Kharif season fruits showing higher protein and carbohydrate levels, while Rabi season fruits exhibited higher concentrations of bioactive compounds such as capsaicin. This suggests that cooler Rabi temperatures may promote the accumulation of secondary metabolites like capsaicin, while the more favourable moisture conditions during Kharif enhance macronutrient synthesis. These seasonal insights are crucial for optimizing chili cultivation practices to maximize both yield and nutritional quality.

This study demonstrates that organic farming practices offer clear advantages over conventional and control farming methods in terms of nutrient composition. By enhancing soil fertility, promoting better water retention, and fostering higher nutrient uptake, organic farming produces chili fruits that are richer in essential nutrients and bioactive compounds. Given the rising consumer demand for nutrient-dense and sustainably produced foods, promoting organic farming in regions like Rajasthan can improve public health outcomes and contribute to environmental sustainability. Moreover, understanding the effects of seasonal variations on nutrient composition allows farmers to make informed decisions regarding the timing of cultivation to optimize the nutritional value of their crops. Therefore, organic farming not only supports healthier diets but also presents a viable solution for sustainable agricultural practices in arid and semi-arid regions like Rajasthan.

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