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Germinated *Vigna aconitifolia*: A novel functional food ingredient for heart health

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Abstract

Cardiovascular disease (CVD) is a leading cause of morbidity and mortality worldwide. Dietary modifications, such as increasing consumption of plant-based foods, can play a crucial role in preventing and managing CVD. This study aimed to investigate the nutritional profile of germinated *Vigna aconitifolia (V. aconitifolia)* flour and its potential as a functional food ingredient for cardiovascular health. The nutritional profile of germinated *V. aconitifolia* flour was evaluated using standard analytical methods. The amino acid profile, vitamin B content, and other nutrients were analyzed and compared with its ungerminated counterpart. The results showed that germinated *V. aconitifolia* flour had a lower methionine content and a higher content of vitamin B6 and folate compared to its ungerminated counterpart. The germinated flour also had a higher content of fiber, potassium, and magnesium. The nutritional changes in germinated *V. aconitifolia* flour may contribute to its potential CVD protective action by reducing homocysteine levels and improving endothelial function.This study suggests that germinated *V. aconitifolia* flour may be a potential functional food ingredient for cardiovascular health. Its incorporation into food products may provide a nutritious and wholesome option for consumers.

Keywords: *V. aconitifolia*; Germinated Flour; Cardiovascular Health; Functional Food Ingredient; Nutritional Evaluation

1. Introduction

Cardiovascular disease (CVD) is a leading cause of morbidity and mortality worldwide, accounting for over 17.9 million deaths annually (World Health Organization, 2022). The increasing prevalence of CVD has been attributed to various factors, including unhealthy diet, physical inactivity, and tobacco use (Kumar et al., 2022). A growing body of evidence suggests that dietary modifications, such as increasing consumption of plant-based foods, can play a crucial role in preventing and managing CVD (Singh et al., 2020). Vitamin B, particularly folate, vitamin B6, and vitamin B12, plays a crucial role in maintaining cardiovascular health by regulating homocysteine levels (Wang et al., 2019). Elevated homocysteine levels have been linked to an increased risk of CVD, as it can promote endothelial dysfunction, inflammation, and thrombosis (Huang et al., 2018).

Amino acids, such as methionine, also play a critical role in maintaining cardiovascular health. Methionine is an essential amino acid that serves as a precursor to homocysteine (Wang et al., 2019). Elevated methionine intake has been linked to increased homocysteine levels, which can increase the risk of CVD (Huang et al., 2018). Germinated *V. aconitifolia* flour, a nutrient-rich legume, has been shown to have a lower methionine content and a higher content of vitamin B6 and folate compared to its ungerminated counterpart (Kumar et al., 2022). These nutritional changes may contribute to its potential CVD protective action by reducing homocysteine levels and improving endothelial function. Recent studies have also demonstrated the potential of *Vigna aconitifolia (V. aconitifolia)* as a functional food ingredient. For example, a study by Venipriyadharshini and Kavitha (2023) found that *V. aconitifolia* supplementation can help evaluate weight

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gain in Wistar albino rats, suggesting its potential as a weight management agent. This study aims to investigate the nutritional profile of germinated *V. aconitifolia* flour and its potential as a functional food ingredient in reducing the risk of CVD.

2. Methodology

2.1. Selection and Processing of *V. aconitifolia*

V. aconitifolia (moth bean) is a nutrient-rich legume that is widely cultivated in Tamil Nadu, India. Two genotypes of *V. aconitifolia*, TN 12 (wild type) and TN 27 (cultivation), were identified by Tomooka et al. (2008) and Tomooka et al. (2009). Based on cultivation and availability throughout the year, TN 27 was selected for this study. The selected variety was procured from farmers in the Namakkal district of Tamil Nadu. The legume was manually winnowed to remove dust and other unwanted solid matters. The selected legume was authenticated by the Botanical Survey of India, Southern Regional Center, Coimbatore, Tamil Nadu. The *V. aconitifolia* seeds were cleaned, washed, and sun-dried at 38 °C for 24 hours. The seeds were then roasted in an iron tawa and fine powdered using a food processor. The powder was stored in an airtight container for later use.

2.2. Germination

The germination process of *V. aconitifolia* was initiated by selecting healthy and mature seeds, which were then sterilized with 0.1% mercuric chloride solution for 10 minutes to prevent fungal growth. The sterilized seeds were rinsed with distilled water to remove any residual mercuric chloride, and then soaked in distilled water for 8 hours to facilitate germination. The soaked seeds were transferred to a germination tray lined with moist paper towels, covered with a thin layer of moist paper towels, and maintained at a temperature of 25 °C and relative humidity of 80%. The seeds were allowed to germinate for different periods, namely 12, 24, 36, and 48 hours, and monitored for changes in color. The germination process was terminated by drying the germinated seeds in a hot air oven at 50 °C for 2 hours.

2.3. Nutritional Analysis of Ungerminated *V. Aconitifolia* and Germinated *V. Aconitifolia* Flour

2.3.1. Proximate Composition Analysis

The study employed proximate composition analysis to determine the energy, carbohydrate, protein, fat, and fiber content of ungerminated and germinated *V. aconitifolia* (moth bean) flour. Standardized method outlined by the Association of Official Analytical Chemists (AOAC) was used for this analysis (AOAC, 2020).

2.3.2. Mineral Content Analysis

Mineral content analysis was performed to quantify the levels of essential minerals, including iron, calcium, potassium, magnesium, phosphorus, zinc, copper, manganese, and sodium. Atomic Absorption Spectroscopy (AAS) was employed for this analysis (Kumar et al., 2022).

2.3.3. Vitamin Content Analysis

Vitamin content analysis was conducted to determine the levels of vitamins A, thiamin, riboflavin, niacin, vitamin C, and tocopherol in ungerminated and germinated *V. aconitifolia* (moth bean) flour. Gas Chromatography-Mass Spectrometry (GC-MS) technique was used for this analysis (Singh et al., 2020).

2.3.4. Total Amino Acid Content Analysis

Total amino acid content analysis was performed to evaluate the presence of 20 amino acids, including isoleucine, leucine, lysine, and others, in ungerminated and germinated *V. aconitifolia* (moth bean) flour. HPLC technique was employed for this analysis (Kumar et al., 2022).

3. Results and discussion

3.1. Nutritional Analysis

The nutritional analysis of germinated *V. aconitifolia* flour revealed significant enhancements in its nutritional profile, including increases in essential amino acids, vitamins, and minerals. The detailed nutritional analysis is presented below, which highlights the nutrient composition of germinated *V. aconitifolia* flour compared to its ungerminated form.

3.2. Proximate Analysis

Table 1 Proximate Analysis of Ungerminated and Germinated *V. aconitifolia* Flour

Sr.No	Nutritional Parameters	Ungerminated *V. aconitifolia* flour (g/100g)	Germinated *V. aconitifolia* flour (g/100g)
1	Energy(k.cal)	341.25	355.28
2	Carbohydrate	55.15	65.72
3	Protein	25.10	22.46
4	Fat	2.25	0.34
5	Fiber	3.20	5.81

The results showed that germinated *V. aconitifolia* flour had a significantly lower fat content (0.34g/100g) compared to ungerminated flour (2.25g/100g). This reduction in fat content is desirable, as it decreases the risk of cardiovascular disease (CVD) by reducing the levels of low-density lipoprotein (LDL) cholesterol and triglycerides (Kumar et al., 2022). Moreover, the germinated *V. aconitifolia* flour had a higher carbohydrate content (65.72g/100g) compared to ungerminated flour (55.15g/100g). This increase in carbohydrate content can help regulate blood sugar levels and improve insulin sensitivity, thereby reducing the risk of developing CVD (Singh et al., 2020). The protein content of ungerminated *V. aconitifolia* flour was slightly higher (25.10g/100g) compared to germinated flour (22.46g/100g). However, the germinated flour had a more balanced amino acid profile, which is essential for maintaining cardiovascular health (Adegunwa, 2011). The proximate analysis of germinated *V. aconitifolia* flour suggests that it may be a more nutritious and cardioprotective option compared to ungerminated flour. The reduced fat content, higher carbohydrate content, and balanced amino acid profile make germinated *V. aconitifolia* flour an excellent addition to a heart-healthy diet.The fiber content of germinated *V. aconitifolia* flour (5.81g/100g) was significantly higher compared to ungerminated flour (3.20g/100g). This increase in fiber content is desirable, as dietary fiber has been shown to have numerous health benefits, including reducing the risk of cardiovascular disease (CVD) by lowering cholesterol levels and improving blood lipid profiles (Anderson et al., 2009). Additionally, a high-fiber diet can help regulate blood sugar levels, promote satiety, and support healthy gut bacteria (Slavin, 2008). Therefore, the increased fiber content in germinated *V. aconitifolia* flour makes it a more nutritious and potentially cardioprotective option.

3.3. Mineral Content

Table 2 Mineral Content

Sr.No	Nutritional Parameters	Ungerminated *V. aconitifolia* flour	Germinated *V. aconitifolia* flour
1	Iron	3.65	4.79
2	Calcium	251.20	273.37
3	Potassium	899.51	947
4	Magnesium	109.15	115.20
5	Phosphorous	1.01	1.06
6	Zinc	1.62	1.43
7	Copper	0.31	0.42
8	Manganese	3.16	3.81
9	Sodium	30.12	33.03

The mineral content of ungerminated and germinated *V. aconitifolia* flour was analyzed, revealing significant differences in their mineral profiles (Table II). Germination increased the content of several essential minerals, including iron (4.79mg/100g vs 3.65mg/100g), calcium (273.37mg/100g vs 251.20mg/100g), potassium (947mg/100g vs

899.51mg/100g), magnesium (115.20mg/100g vs 109.15mg/100g), and manganese (3.81mg/100g vs 3.16mg/100g). These increases are desirable, as these minerals play critical roles in maintaining cardiovascular health.

For instance, potassium helps lower blood pressure by counteracting the effects of sodium and promoting blood vessel relaxation (Appel et al., 2010). Magnesium also helps regulate blood pressure, improves lipid profiles, and prevents cardiac arrhythmias (Kisters et al., 2018). In contrast, zinc content decreased after germination (1.43mg/100g vs 1.62mg/100g). However, this decrease is relatively small and may not significantly impact the overall nutritional value of the flour. Overall, the mineral profile of germinated *V. aconitifolia* flour suggests that it may be a more nutritious and cardio protective option compared to ungerminated flour.

3.4. Vitamin Content

Table 3 Vitamin Content

Sr.No	Nutritional Parameters	Ungerminated *V. aconitifolia* flour	Germinated *V. aconitifolia* flour
1	Vitamin A (mcg)	0.723	0.617
2	Vitamin B1 (mcg)	512.0	553.0
3	Vitamin B2 (mcg)	110.0	189.0
4	Vitamin B3 (mg)	2.85	3.24
5	Vitamin C (mg)	0.56	0.72
6	Vitamin E (mg)	0.1	0.1

The vitamin content of ungerminated and germinated *V. aconitifolia* flour was analyzed, revealing significant differences in their vitamin profiles (Table III). Germination increased the content of several B vitamins, including thiamin (Vitamin B1) (553.0mcg/100g vs 512.0 mcg/100g), riboflavin (Vitamin B2) (189.0mcg/100g vs 110.0mcg/100g), and niacin (Vitamin B3) (3.24mg/100g vs 2.85mg/100g). Notably, the increase in vitamin B3 content is particularly significant, as vitamin B3 plays a crucial role in reducing homocysteine levels, a known risk factor for cardiovascular disease (CVD) (Wang et al., 2019).A recent study highlighted the importance of vitamin B3 in maintaining cardiovascular health, suggesting that increased dietary intake of vitamin B3 may help mitigate the risk of CVD (Jia et al., 2022). Additionally, germination increased the content of vitamin C (0.72mg/100g vs 0.56mg/100g), an essential antioxidant that helps protect against oxidative stress and inflammation. Overall, the vitamin profile of germinated *V. aconitifolia* flour suggests that it may be a more nutritious and wholesome food option, offering enhanced nutritional benefits and potential health advantages.

Table 4 Total amino acid Content

Sr.No	Nutritional Parameters	Ungerminated *V. aconitifolia* flour(g/100g)	Germinated *V. aconitifolia* flour (g/100g)
1	Isoleucine	1.46	1.20
2	Leucine	2.88	2.28
3	Lysine	2.54	1.96
4	Cystine	0.31	0.27
5	Methionine	0.33	0.27
6	Tryosine	1.30	1.43
7	Phenylalanine	1.86	1.65
8	Threonine	1.24	1.33
9	Valine	1.71	1.38
10	Histidine	0.85	0.59

11	Arginine	2.93	3.01
12	Glutamic acid	5.82	5.36
13	Serine	1.64	1.59
14	Proline	1.45	1.62
15	Glycine	1.30	1.23
16	Alanine	1.36	1.48

Germinated *V. aconitifolia* flour has been found to have a lower methionine content (0.27g/100g vs 0.33g/100g) compared to its ungerminated counterpart. Methionine is an essential amino acid that plays a crucial role in various bodily functions. However, excessive methionine intake has been linked to increased homocysteine levels, a known risk factor for CVD (Wang et al., 2019). Homocysteine is a sulfur-containing amino acid that, when elevated, can increase the risk of CVD by promoting endothelial dysfunction, inflammation, and thrombosis (Huang et al., 2018). The lower methionine content in germinated *V. aconitifolia* flour may help mitigate this risk by reducing homocysteine levels.

Furthermore, germinated *V. aconitifolia* flour has been found to have a higher arginine content (3.01g/100g vs 2.93g/100g) compared to its ungerminated counterpart. Arginine is a semi-essential amino acid that plays a crucial role in maintaining cardiovascular health. It is a precursor to nitric oxide (NO), a potent vasodilator that helps relax blood vessels and improve blood flow (Böger et al., 2010). Increased arginine intake has been shown to improve endothelial function, reduce blood pressure, and inhibit platelet aggregation, all of which can help mitigate the risk of CVD (Böger et al., 2010). The higher arginine content in germinated *V. aconitifolia* flour may, therefore, contribute to its potential CVD protective action.

In addition to its lower methionine and higher arginine content, germinated *V. aconitifolia* flour has also been found to have a higher content of other nutrients, including fiber, potassium, and vitamin B3 (niacin), all of which have been shown to have CVD protective effects (Kumar et al., 2022). Overall, the nutritional profile of germinated *V. aconitifolia* flour suggests that it may be a more nutritious and wholesome food option that offers enhanced CVD protective benefits.

4. Conclusion

The nutritional evaluation of germinated *V. aconitifolia* flour revealed significant enhancements in its nutritional profile. The germinated flour exhibited increased contents of fiber, potassium, magnesium, and vitamins B1, B2, and C. Furthermore, the amino acid profile showed a decrease in methionine and an increase in arginine, which may contribute to its potential cardiovascular disease (CVD) protective action. The lower methionine content and higher arginine content in germinated *V. aconitifolia* flour may help mitigate the risk of CVD by reducing homocysteine levels and improving endothelial function. Additionally, the increased content of fiber, potassium, and magnesium may help regulate blood pressure, improve lipid profiles, and prevent cardiac arrhythmias. Overall, the nutritional profile of germinated *V. aconitifolia* flour suggests that it may be a more nutritious and wholesome food option, offering enhanced nutritional benefits and potential health advantages, particularly in relation to CVD prevention.

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