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Nutritional Quality of Green Leafy Vegetable Enriched "Appalu" –A Popular Telangana Traditional Snack

Arrabothu Dharani[1], Janaki Srinath Puskuri[2*], T. Kamalaja[3] and K. Supriya[4]

[1]Department of Foods and Nutrition, Post Graduate Research Centre, PJTS Agricultural University, Rajendranagar, Hyderabad (Telangana), India.
[2]Assistant Professor, Department of Foods and Nutrition, College of Community Science, Saifabad, PJTS Agricultural University, Rajendranagar, Hyderabad (Telangana), India.
[3]Senior Scientist, AICRP-WIA, Department of Foods and Nutrition, PGRC, PJTSAU, Rajendranagar, Hyderabad (Telangana), India.
[4]Professor & Head, Department of Statistics & Mathematics, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad (Telangana), India.

(Corresponding author: Janaki Srinath Puskuri)*
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ABSTRACT: Traditional foods, which are frequently connected to regional culture, are made locally using particular ingredients and rely on the skills and knowledge of the local people. A study was conducted to evaluate the nutritional quality of the popular Telangana snack "Appalu" (Fried flattened discs made with rice flour, ground nuts, pulses and spices) by enriching with dehydrated green leaf powders. These products were evaluated for proximates and minerals such as iron, zinc, sodium, potassium, calcium. Results showed that curry leaves enriched appalu (CGSO) has high amount of protein (16.41g/100g), crude fibre (2.41g/100g), iron (6.41mg/100g), calcium (310.5mg/100g), copper (1.38mg/100g) and zinc (1.92mg/100g) while fat, and ash content was highest in moringa leaves enriched appalu (MGSO) (26.42g/100g), (3.35g/100g) respectively. Sodium content is highest in ponnaganni enriched appalu (PGSO) (601.4mg/100g). There is statistically significant difference (p≤0.05) in proximate and mineral content between control appalu and all green leafy vegetable enriched appalu. It can be concluded that all the proximate composition and the mineral content was higher in the green leafy enriched appalu than the control appalu. Incorporating green leafy vegetable powders into appalu is a convenient method to combat micronutrient malnutrition.

Keywords: Traditional foods, Snacking, Dehydrated green leaves, Micronutrient deficiency, Enrichment, Healthy snack.

INTRODUCTION

Snacking is a significant consumption pattern that can help children meet their daily nutrient needs for healthy growth and development (Serrano and Powell 2013). Traditional snacks, which are frequently associated with regional foods, are produced locally using specific regional ingredients and rely on the skills and knowledge of the community (Tokiman *et al*., 2019).

According to (Asokapandian *et al.,* 2020) frying increases the food's palatability, extends its shelf life, and allows for the fabrication of a variety of dishes, which have distinctive sensory qualities that make them highly appealing to customers.

In India people prepare traditional snacks which are ready to eat, have substantial shelf life at home for festivals, during holidays and special occasions such as weddings. Popular traditional snacks of India include shakarpara, murukhu, khakhra, sev, mathri, mixture, khara bhoondhi etc. In Telangana, popular snacks include aaku pakodi, appalu, murukulu, chekodilu, chekralu, sakinalu, janthikalu and mixed boondhi, etc. In the Telangana region, "appalu" are a widely consumed and favored traditional deep-fried snack, is made of rice flour, peanuts, chanadhal, black eye bean dal with an addition of other ingredients which includes sesame seeds, spices such as green chilli paste/ chilli powder, curry leaves, spring onion leaves, garlic and salt. 100 g of appalu has a nutrient content of 53g of carbohydrates, 14g of protein, 23g of fat apart from other nutrients.

Growing concern has increased in recent years about the nutrient supply for the world's population growth, particularly the inadequate supply of essential micronutrients. Over one-fourth of the world's population suffers from micronutrient deficiencies, a biggest challenge in public health (Gonmei and Toteja 2018).

Fortification and enrichment of food are looked upon potential vehicles to enhance micronutrients in foods (Verma and Jain 2012). Traditional preparations, when incorporated with green leafy vegetables could serve a

means of enhancing nutritive value particularly essential micro nutrients of food.

Dehydration is the simplest convenient technology for preserving the micronutrients, especially when foods are abundantly available in a particular season. Dried green leafy vegetable powders are concentrated natural source of micronutrients that can be incorporated into product formulations. Value addition of traditional foods with dehydrated GLV can be recommended as a feasible food-based approach to combat micronutrient malnutrition (Gupta *et al*., 2013).

As a way to modify the conventional products to enhance nutrients and create value-added items that are acceptable, incorporation was attempted. In order to increase the use of dehydrated green leafy vegetables in traditional dishes and ensure the security of micronutrients, the present study was taken up to use the most frequently consumed GLVs such as amaranth leaves, curry leaves, moringa leaves, ponnaganni leaves in a dehydrated form incorporated into acceptable popular snack "Appalu".

Amaranth leaves (*Amaranth viridus*) are a good source of carotenoids, proteins, dietary fiber, and minerals like magnesium, calcium, potassium, copper, phosphorus, zinc, iron, and manganese at a reasonable price. In addition, amaranth is rich pigments, including chlorophylls, amaranthine, anthocyanins, betalains, beta xanthins, and betacyanins, as well as naturally occurring antioxidants like phytochemicals, including vitamin C, beta carotene, flavonoids, and phenolic acids, which act as ROS scavengers in the body Sarker *et al*. (2020).

Curry leaves (*Murraya koenigi*) are high in fiber, carbohydrate, and vitamins like thiamine, niacin, ascorbic acid, and retinol. They are also high in minerals like phosphorus, calcium, iron, zinc, potassium, and manganese. Curry leaves contain a variety of phytochemicals, such as terpenes, alkaloids, flavonoids, and tannins. Bioactive compounds with reported antimicrobial and antioxidant activity include bicyclomahanimbiline, girinimbilyl acetate, and mahanimbilyl acetate.

Moringa (*Moringa oleifera*) contains a significant nutritional composition that is high in protein and dietary fibre. The leaves are a good source of important vitamins, amino acids, and fatty acids. It contains B complex vitamins like B6, vitamin A, C, and E in addition to micronutrients like iron, magnesium, and folate (Patil *et al*., 2022).

Ponnaganni (*Alternantherea sessillis*), also known as sessile joy weed and dwarf copperleaf, is an underutilized GLV. The leaves of ponnaganni are a good source of phosphorous, vitamin B1, beta-carotene, carbohydrate, dietary fiber, and protein (Hameed *et al*., 2021).

MATERIALS AND METHODS

A. Raw material

Rice, Groundnuts and Sesame and other ingredients like red chilli powder, garlic paste, oil, cumin seeds were procured from the market of Rajendranagar, Hyderabad.

All green leafy vegetables i.e., *Amaranth viridus* (Amaranth), *Murraya koenigii* (curry leaves), *Moringa oleifera* (Moringa), *Alternanthera sessilis* (Ponnanganni) were procured from the market of Mehdipatnam, Hyderabad.

B. Process standarisation of control appalu

Weighing: All the major ingredients were weighed in the proportion of 55:36:9: (Rice flour: Groundnuts: Sesame).

Preparation of dough: All the ingredients i.e., rice flour, sesame, groundnuts, chilli powder, cumin seeds, coriander powder, garlic paste, salt were mixed together with water and kneaded to form dough. The prepared dough is kept aside for 5 minutes.

Preparation of appalu: Prepared dough is made into small balls and with the help of puri presser. Small dough balls are made into flattened thin disc with the diameter of 2.5 cm.

Frying: Prepared appalu were deep fried in preheated oil and were allowed to cool.

Storage: Appalu were stored in an air tight container after cooling for further analysis.

Plate 1. (Control appalu).

C. Process standardization of green leafy vegetable enrinched appalu.

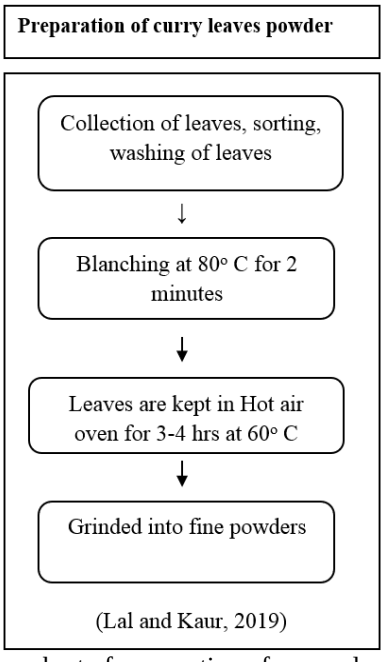

Fig. 1. Flowchart of preparation of curry leaf powder.

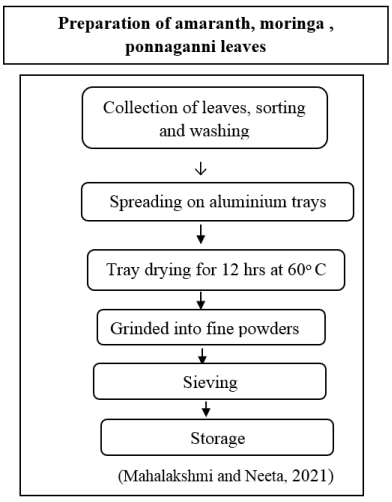

Fig. 2. Flowchart of preparation of amaranth, moringa, ponnaganni leaves powder.

(i) Preparation of dehydrated green leaf powders. Curry leaves were dehydrated by the procedure given by Lal and Kaur (2019) and amaranth, moringa and ponnaganni leaves were dehydrated by the method given by (Mahalakshmi and Neeta 2021) as per the process explained in Fig. 1 and 2.

(ii) Preparation of green leafy enriched appalu

Weighing- All the major ingredients were weighed in the proportion of 55:36:9: (Rice flour: Groundnuts: Sesame). 5% of GLVs i.e., amaranth, curry, moringa, and ponnaganni leaves were incorporated separately in control appalu.

Preparation of dough- All the ingredients i.e., rice flour, groundnuts, seseame, chilli powder, salt, cumin seeds, garlic paste, green leaf powders, according to required proportions were mixed together with water and kneaded to form dough. Then the dough is kept aside for 5 minutes.

Preparation of appalu- Prepared dough is made into small balls with the help of puri presser. These small dough balls are made into flattened thin disc with the diameter of 2.5 cm.

Frying- Prepared appalu was deep fried in preheated oil and were allowed to cool.

Storage-Appalu were stored in an air tight container after cooling for further analysis.

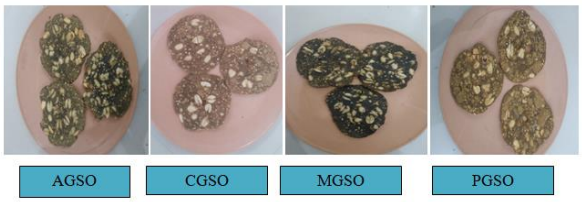

Plate 2. (Green leafy vegetable enriched appalu).

AGSO-Amaranth leaves enriched appalu
CGSO-Curry leaves enriched appalu
MGSO-Moringa leaves enriched appalu
PGSO-Ponnaganni leaves enriched appalu

D. Proximate analysis

Proximate content of appalu were analyzed using standard protocols as described.

(i) Determination of moisture content: Standard protocol (AOAC, 2005) was used for moisture estimation.5g of the sample was dried in a hot air oven for 2 hours at 105°C. Sample was cooled in a desiccator for two hours before being weighed. This was carried out repeatedly every 30 minutes until the desired weight was attained. The moisture content of the sample was expressed in g/100 g of sample.

(ii) Determination of protein content: Using pelican kelplus equipment and the micro kjeldahl method (AOAC, 2010) the amount of crude protein was determined. It was calculated by multiplying the result by a factor of N × 6.25, expressed as g/100 g.

(iii) Determination of fat content: Soxhlet method (AOAC, 2005) was used to estimate fat content and expressed as g/100 g.

(iv) Determination of ash content: Total ash was estimated using a standard protocol (AOAC, 2005) where 5 g of dried sample was weighed in a crucible, ignited till it was charred completely. The charred sample was put into the crucible and kept in the muffle furnace for about 4 hours at 600°C till white or greyish color ash was obtained. It was then brought to room temperature, cooled in a desiccator, and weighed.

(v) Estimation of carbohydrates: Carbohydrates was estimated by difference method using the formula:

Carbohydrate (%) = 100 – (% Moisture + % Ash + % Fat + % Protein)

(vi) Determination of crude fiber: Moisture and fat-free samples were used for estimating crude fiber. Samples were treated with acid followed by an alkali bath as described in standard (AOAC, 2005) protocol. The residue obtained after final filtration was weighed, incinerated, cooled, and weighed again. Crude fiber content was expressed as g/100 g of the sample.

(vii) Determination of mineral content. Moisture-free samples were wet digested in a microwave digester using nitric acid. Further iron, copper, zinc content was determined as described in standard protocol (AOAC, 2000) using atomic absorption spectrophotometer and sodium, and calcium were estimated using flame photometry (AOAC, 2000).

E. Statistical analysis

One-way analysis of variance (ANOVA) was used to determine statistical significance. At the 5% level ($p \leq 0.05$), differences in means were considered statistically significant.

RESULTS AND DISCUSSION

A. Proximate composition

The nutritional quality of any food product can be evaluated using the proximate content as a key factor. The data on proximate composition of four green leafy vegetable enriched appalu along with the control appalu are summarized under Table 1.

Table 1: Nutritional composition of appalu per 100g.

Types	Moisture (%)	Protein(g)	Fat(g)	Ash(g)	Crude fibre(g)	Carbohydrates(g)
GNSO	3.84^{e}±0.26	14.18^{e}±0.17	23.72^{e}±0.49	3.23^{d}±0.13	1.21^{e}±0.04	55.03^{a}±0.74
AGSO	5.94^{b}±0.03	15.07^{d}±0.09	24.50^{d}±0.31	4.20^{a}±0.09	2.28^{c}±0.10	51.95^{b}±0.36
CGSO	5.40^{d}±0.18	16.41^{a}±0.16	25.71^{b}±0.24	3.35^{c}±0.15	2.41^{a}±0.16	48.18±0.16
MGSO	5.66^{c}±0.06	15.66^{b}±0.23	26.42^{a}±0.23	3.35^{c}±0.26	2.33^{b}±0.18	48.9±0.05
PGSO	6.56^{a}±0.06	15.45^{c}±0.28	25.46^{c}±0.28	3.49^{b}±0.40	2.24^{d}±0.24	47.61^{c}±0.64

Note: Values are expressed as mean ± standard deviation of three determinations; Means within the same column followed by a common letter do not differ significantly at ($p \leq 0.05$).
Where,
GNSO - Control appalu; AGSO - Amaranth leaves enriched appalu; CGSO - Curry leaves enriched appalu; MGSO- Moringa leaves enriched appalu; PGSO - Ponnaganni leaves enriched appalu.

The maximum moisture content was present in PGSO (6.56±0.06%) followed by AGSO (5.94±0.03%), MGSO (5.66±0.06%), CGSO (5.40±0.18%). The least moisture content was found in GNSO (3.84±0.26%). There was statistically significant difference (p≤0.05) in moisture content between control appalu and green leafy vegetable enriched appalu. The addition of powdered green leafy vegetables increased the moisture content. Similar findings were found by Kolawole *et al*. (2013) who added moringa powder to the wheat cake.

The maximum protein content was observed in CGSO (16.41±0.03g), followed by MGSO (15.66±0.23g), AGSO (15.07±0.05g), PGSO (15.45±0.28g), GNSO (14.18±0.17g). There is statistically significant difference (p≤0.05) in the protein content between the control appalu and green leafy vegetable enriched appalu. Similar findings were found by (Joshi and Mathur 2015) who added powder of leaf mixture to mathri and pakora.

Similar to protein, fat content was high in green leafy enriched appalu than in control appalu. The maximum fat content was observed in MGSO (26.42±0.23g) followed by CGSO (25.71±0.24g), AGSO (24.50±0.31g), PGSO (25.46±0.28g). This may due to extra fat content that is present in green leafy vegetables and also due to the absorption of moisture content in the green leafy vegetables enrichment. The least fat content was observed in GNSO (23.72±0.49g). There was statistically significant difference (p≤0.05) between control appalu and green leafy vegetable enriched appalu.

It is observed that the ash content is highest in AGSO (4.20±0.09g), followed by PGSO (3.49±0.40g), MGSO (3.35±0.26g), CGSO (3.35±0.15g). The least ash content is found in GNSO (3.23±0.13g). There was statistically significant difference (p≤0.05) for GNSO, AGSO, PGSO and no significant difference between CGSO, MGSO.

According to Srinivasamurthy *et al*. (2017) the addition of dried moringa leaf powder to muffin recipes increased the ash content of the final product due to the dried moringa leaf powder's higher mineral content.

It is reported that the crude fibre is highest in CGSO (2.41±0.16g) followed by MGSO (2.33±0.18g), AGSO (2.28±0.10g), PGSO (2.24±O.24g), GNSO (1.21±0.04g). There was statistically significant difference (p≤0.05) between the control appalu and green leafy vegetable appalu.

Galla *et al*. (2017) has reported an increase in the crude fibre of spinach powder supplemented biscuits from 5.88% (without greens) to 27.8% (with greens) made with incorporation of spinach powder to the biscuits.

Carbohydrate content is highest in GNSO, followed by AGSO (51.95±0.36g), PGSO (47.61±0.64), MGSO (48.9±0.05), CGSO (48.18±0.16g). There was statistically significant difference (p≤0.05) between the control appalu and green leafy vegetable enriched appalu. Addition of green leafy vegetable powders lead to decrease in the carbohydrate content in AGSO, CGSO, MGSO, PGSO samples. Similar findings were found by (Elsebaie and Mostafa 2018) who added dried stevia leaves powder to the cakes.

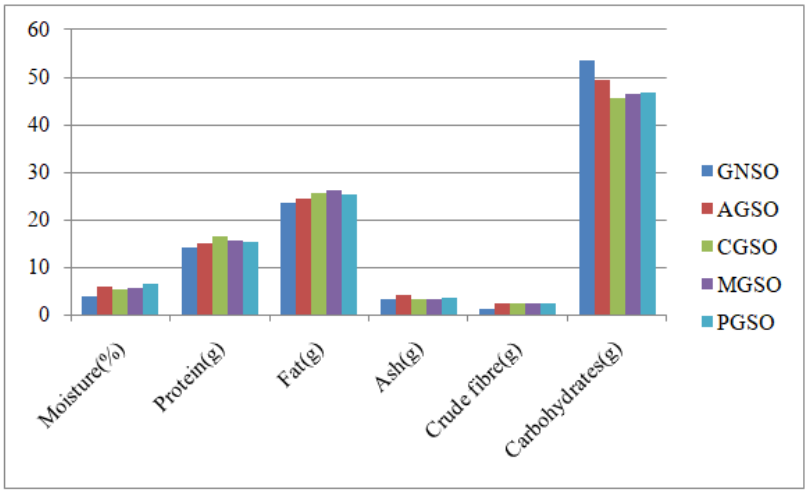

Fig. 3. Proximate composition of appalu.

B. Mineral content

The results presented in Table 2, exhibits a significant difference in mineral content of control and green leafy vegetable enriched appalu.

It is observed that iron content is highest in CGSO (6.41±0.17mg), followed by PGSO (4.10±0.1mg), AGSO (3.64±0.08mg), MGSO (3.44±0.5mg), GNSO (3.10±0.5mg). Statistically significant difference ($p \leq 0.05$) was found between the control appalu and green leafy vegetable enriched appalu. Similar findings were found by (Srinivasamurthy *et al*., 2017) who added moringa leaves to muffins.

Copper content is highest in CGSO (1.38±0.04mg), followed by MGSO (1.32 ±0.03mg) AGSO (1.21±0.10mg), PGSO (1.20±0.11mg), GNSO (0.80±0.02mg). There was statistically significant difference ($p \leq 0.05$) for CGSO, MGSO, GNSO and no significant difference ($p \leq 0.05$) for AGSO and PGSO.

Zinc content is highest in CGSO (1.92±0.04mg), followed by AGSO (1.83±0.03mg), MGSO (1.78±0.02mg), PGSO(1.75±0.07mg). The least content is reported in GNSO (1.45±0.29). There was statistically significant difference ($p \leq 0.05$) between CGSO, AGSO, GNSO and no significant difference ($p \leq 0.05$) for MGSO, PGSO. Similar findings were found by (Ramya and Chandrashekhar 2020) who added mulberry leaves to chapathi mix.

Sodium content is highest in PGSO (601.4±0.9mg) followed by MGSO (556.2±1.04mg), CGSO (541.2±1.25mg), AGSO (521.2±1.04mg), GNSO (507.5±0.5mg). Statistically significant difference ($p \leq 0.05$) was found between the control appalu and green leafy vegetable enriched appalu.

It is observed that calcium content is highest in CGSO (310.5±0.50mg), followed by MGSO (267.0±2mg), AGSO (256.2±0.76mg), PGSO (210.5±3mg), GNSO (111.0±0.5mg). There was statistically significant difference ($p \leq 0.05$) between the control appalu and green leafy vegetable enriched appalu. Similar findings were found by Sharma *et al*. (2013) who added dried guduchi leaf powder to the cookies.

Table 2: Mineral content of appalu per 100 g.

Types	Fe(mg)	Cu(mg)	Zn(mg)	Na(mg)	Ca(mg)
GNSO	3.10^{e}±0.05	0.80^{d}±0.02	1.45^{d}±0.29	507.5^{e}±0.5	111.0^{e} ±0.5
AGSO	3.64^{c}±0.08	1.21^{c}±0.10	1.83^{b}±0.03	521.2^{d}±1.04	256.2^{c}±0.76
CGSO	6.41^{a}±0.17	1.38^{a}±0.04	1.92^{a}±0.04	541.2^{c}±1.25	310.5^{a}±0.50
MGSO	3.44^{d}±0.05	1.32^{b}±0.03	1.78^{c}±0.02	556.2^{b}±1.04	267.0^{b}±2
PGSO	4.10^{b}±0.1	1.20^{c}±0.11	1.75^{c}±0.07	601.4^{a}±0.9	210.5^{d}±3

Note: Values are expressed as mean ± standard deviation of three determinations; Means within the same column followed by a common letter do not differ significantly at ($p \leq 0.05$)

GNSO- Control appalu; AGSO- Amaranth leaves enriched appalu; CGSO-Curry leaves enriched appalu' MGSO-Moringa leaves enriched appalu; PGSO- Ponnaganni leaves enriched appalu

CONCLUSIONS

The protein, fat, ash, and crude fibre, and mineral content was significantly higher in green leafy enriched appalu compared to control appalu. The production of healthier foods is presently the main focus of food processing industry for nutritional security. On the basis of the present study, it may be concluded that appalu can be prepared with incorporation of green leafy vegetable powders to enhance nutrition. As appalu are already a popular snack so it would be convenient way to incorporate green leafy vegetables with complete consumer acceptability. On the basis of the present study it can be concluded that green leafy vegetables has great scope in the field of value added recipes development and commercialization.

FUTURE SCOPE

Other underutilized leafy vegetables can be explored for incorporation. These products could be made accessible to the general public and can be scaled up to an industrial level.

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Conflict of Interest. None.

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