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Technology for commercial production of cashew sprouts, a traditional delicacy of Kerala

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Abstract
Cashew sprouts are highly nutritious and a potential additive to a healthy diet. Experiments were conducted at the Cashew Research Station, Kerala Agricultural University, Madakkathara, to evaluate the nutritional quality of cashew sprouts and assess the harvest stage on yield and quality of sprouts, and to study the effect of pre-sowing treatments on germination and recovery. The cashew sprouts recorded 2.48 per cent of total sugars, 4.70 g/100g of protein, 17.18 per cent of fat, 3.6 g/100g of free amino acid, 420 mg/100g of phenol, 2.8 mg/100g of tannin, and 22.22 mg/100g of iron and 64.2 mg/100g of calcium. Cotyledon recovery was the highest (62 to 68 %) and at par in all harvest stages except the leaf unfurling stage (51%). Total sugar content increased from 1.9 per cent at the cotyledon emergence stage to 2.3 per cent at the plumule emergence and leaf unfurling stages. Polyphenol content was highest at the cotyledon emergence stage (1.18%), while free amino acids were lowest (2.53 mg/100). The lowest tannin content was recorded in cotyledons harvested at plumule emergence stage (4.54 mg/100g). Cashew nuts pre- soaked for 72 and 96 hours in water gave higher germination percentage of 95.3 and 90.3, respectively. Pre-soaking of cashew nuts for 72 hours and harvesting at the plumule emergence stage resulted in quality cashew sprouts with higher yield (544.10 g $0.2m^{-2}$)

Keywords: Cashew sprout, Cotyledon emergence, Pre-soaking, Processed kernel, Nutritional qualities.

Introduction

The humid tropical climate of Kerala, the southernmost state of India, favours the growth of cashew. The processed cashew kernels from raw nuts are the main economic product of the tree. In late bearing varieties of cashew, nut maturity coincides with heavy rain. The nuts, which lie hidden among fallen leaves and grasses and thus escaped collection, would germinate in the monsoon rains. The germinated nuts or cashew sprouts are relished in their raw form or in curries, and are a traditional delicacy among rural people in Kerala. In addition to being delicious, sprouts are reported to be highly nutritious and lower in anti-nutritional factors (Fagbemi et al., 2005; Preethi and Mangalassery, 2019) and so can be a potential functional food.

Sprouts and microgreens are popular ready-to-eat food sources for healthy diets (Ebert, 2022). They contain more soluble sugars, amino acids, and nutrients than seeds. They have a distinct flavour, and numerous health benefits are attributed to sprouts of various cereals (Nkhata et al., 2018), pulses (Bains et al., 2014) and oilseeds (Bhardwaj and Hamama, 2007; Xiao et al., 2022), as well as microgreens (Zielin´ski et al., 2005). Sprouts are a good source of essential phytonutrients that are protective. Legumes, cereals, pseudocereals, oilseeds, vegetables, and herbs are mainly used to produce either sprouts or shoots with fully expanded cotyledons, i.e., microgreens (Ebert, 2012).

The development of a production technology to optimize yield and quality of cashew sprouts could

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pave the way for the commercialization of this product. Published literature on the potential effect of pre-sowing treatments in a forced production system and the stage of harvest on the yield and quality of cashew sprouts are lacking. Understanding these would help produce traditional cashew sprouts with optimum quality, which would greatly improve their commercial value. In this background, the present investigation was carried out.

Materials and Methods

The study was conducted at Cashew Research Station, Madakkathara, in the central part of Kerala (India) under the Kerala Agricultural University, and consisted of three parts. The first investigation was on the nutritional composition of cashew sprouts and processed kernels. The cashew kernels were prepared by steam roasting. Total sugars, protein, crude fibre, crude fat, calcium, iron, phenols, tannins, and total free amino acids in the sprouts as well as in processed cashew nuts were estimated using the procedures suggested by Sadasivam and Manickam (1996). In the second experiment, the effect of the stage of the harvest of sprouts on production and phytochemical constituents was assessed, while in the third part, the effect of pre-sowing treatments on yield and quality of sprouts was evaluated,

The dried cashew seed nuts with a moisture content of 8 per cent were washed and cleaned thoroughly

Plate 1. Emerging cashew sprouts

Plate 2. Harvested cashew cotyledons

Plate 3. Stages of sprout emergence: 1. Cotyledon emergence 2. Cotyledon splitting 3. Plumule emergence 4. Leaf unfurling stage

and germinated in a germination chamber (average relative humidity 80-85 %) under etiolated hygienic conditions during May 2021. The viable seeds were sorted by float and sink method (Mandal, 2000), and floating seeds were discarded. The seeds were pre-soaked in water for 48 hours, changing the water daily. The soaked seeds were then sown in coir pith compost media in trays which were kept in a germination chamber. After germination (Plate 1), the intact cotyledons in the emerging seed sprouts were extracted, and the radicle and plumule were removed on the day of emergence (Plate 2). They were collected in 5 per cent salt solution to reduce microbial contamination and pre-treated with the anti-oxidant ascorbic acid to arrest browning.

In the second experiment, nuts were sown as in experiment I. On germination, sprouts were harvested at four stages: cotyledon emergence, cotyledon splitting, plumule emergence and leaf unfurling stage (Plate 3). The experiment was laid out in a completely randomized design. Three replications were maintained, each composed of thirty nuts. The total weight of sprouts, lengths of plumule and radicle, length and width of cotyledons and weight of cotyledons were measured after the extraction of cotyledons. The recovery percentage of cotyledons was also calculated based on the initial nut weight.

In the experiment on pre-sowing priming treatments, the cleaned cashew nuts were immersed in thirteen treatment combinations of clean water and salt water. In each soaking treatment, the water or salt solution was changed daily. The treatments were: S_1 (control, without pre-soaking), S_2 (soaking in water for 8 hours), S_3 (soaking in water 16 hours), S_4 (soaking in water for 24 hours), S_5 (soaking in water for 48 hours), S_6 (soaking in water for 72 hours), S_7 (soaking in water for 96 hours), S_8 (soaking in 0.1% salt solution for 8 hours), S_9 (soaking in 0.1% salt solution 16 hours), S_{10} (soaking in 0.1% salt solution for 24 hours), S_{11}(soaking in 0.1% salt solution for 48 hours), S_{12} (soaking in 0.1% salt solution for 72 hours), S_{13} (soaking in 0.1% salt solution for 96 hours). A completely randomized design with three replications was adopted. Each replication was composed of thirty nuts.

The nuts were then sown in coir pith compost media in protrays of 1.5-inch cavity size and kept in germination chambers at a relative humidity of 80-85 per cent in etiolated condition. The ratio between the number of seeds germinated and the number of seeds sown was calculated and expressed as germination per cent (Hamawa et al., 2019). Mean germination time (MGT) was calculated as Ellis and Roberts (1980) suggested. The yield of cotyledons from sprouts was also recorded and expressed in g0.2 m^{-2}. Statistical data analysis was done in the R based software GRAPES (Gopinath et al., 2020).

Results and Discussion

Nutritive value of cashew sprouts

Data on the total sugars, protein, crude fibre, crude fat, phenols, calcium, and iron content in cashew sprouts as compared to that in processed cashew kernel are presented in Table 1. Cashew sprouts recorded 2.48 per cent of total sugar and 4.70 g/ 100 g of protein, while the total sugar and protein content were 7.17 per cent and 11.90 g/100g in processed kernels. The fat content in processed cashew kernel was 47.6 per cent, whereas it was 17.18 per cent in cashew sprout. Preethi and Mangalassery (2019) also reported less fat content in cashew sprout than processed nut. The energy and amino acids required for the plant's development were produced by the metabolism of lipids, carbohydrates, and storage proteins in the seed (Bewley and Black, 1994; Tharanathan and Mahadevamma, 2003). The seed germination was reported to occur under the dark condition without additional nutrition. Total free amino acids were 3.6 g/100g in sprouts and 0.8 g/100g in kernels from processed nuts. Suda et al. (1986) also reported that the proteins were broken down to amino acids during germination by hydrolytic enzymes.

At the same time, phenolics and other compounds would be synthesized as protective responses (Gharachorloo et al., 2013). In the present study, phenol content in the sprouts was 420 mg/100g. High antioxidant property was conferred to the sprouts by the high phenolic content (Ramesh et

Table 1. Nutritional composition of cashew sprouts and processed cashew kernels

Parameter	Cashew sprouts	Processed cashew kernel
Total Sugars (%)	2.48	7.17
Protein (g/100g)	4.70	11.90
Crude Fibre (%)	9.80	4.75
Crude Fat (%)	17.18	47.60
Calcium (mg/100g)	64.20	37.20
Iron (mg/100 g)	22.22	5.18
Phenols (mg/100g)	420	270
Tannins (mg/100g)	2.80	0.90
Total free amino acids (g/100 g)	3.6	1.80

al., 2011), and the risk of many health problems could be reduced by consuming foods rich in phenolic compounds (Singh et al., 2017). A higher demand for oxygen during the early stages of germination could lead to potential oxidation-induced deterioration, which was prevented by the phenols playing a protective role (Randhir et al., 2004). Significant changes in the phenolic compounds and antioxidant activity in pulses on sprouting were reported by Gharachorloo et al. (2013). The potential protective effects of sprouts showed a positive correlation with prevention from cancer (Haddad et al., 2005).

The tannin content was 0.90mg/100g in the processed cashew kernel as compared to 2.80 mg/100g in the sprouts. The increase in tannin content is not necessarily negative, as tannins help to overcome adverse conditions during germination and attacks from microorganisms, in addition to having human health benefits (Schofield et al., 2001).

The internal chemical changes in the germination process of a seed improved the digestibility and availability of nutritional components. As the beneficial enzymes were unlocked in the germination process, the bioavailability of nutrients would become easy. The calcium and iron contents were 64.20 mg/100g and 22.22 mg/100 g in the cashew sprouts, while it was 37.20 mg/100g and 5.18 mg/100g in the processed nuts, respectively. Similar results were reported by Preethi and Mangalassery (2019). Ready-to-eat cruciferous sprouts were reported to contain higher amounts of Ca, Mg, Cu, and Zn than the seeds (Zielin´ski et al., 2005). Ghavidel and Prakash (2007) found that germination caused a significant increase in *in vitro* iron and calcium bioavailability in legume seeds. Cashew sprouts were also a rich source of iron, and the content was 3-5 times more than that in green leafy vegetables (Longvah et al., 2017).

Effect of stage of harvest

The total weight of cashew sprouts, including the radicle and plumule, was not significantly affected by the stage of harvest (Table 2). The weight of cotyledon harvested from the stages of cotyledon emergence to plumule emergence did not vary significantly and ranged from 3.83g to 4.06g. However, at leaf unfurling stage, the cotyledon weighed significantly less (2.91g). The same trend was seen with regard to the recovery of cotyledons from sprouts (62% to 68%).

The plumule length was greatest when harvesting was done at the leaf unfurling stage, and lowest at the cotyledon emergence stage, while the radicle length did not vary significantly. The length, width, and weight of cotyledon were significantly affected by the time of harvest. The length (6.38cm), width (2.51cm), and weight (3.83g) of cotyledons were significantly high at the plumule emergence stage, with a recovery of 62 per cent.

The appropriate harvest stage for Korean peanut sprouts was reported to be from day 5 to day 8 and was seen to decrease on day 9 (Adhikari et al.,

Table 2. Effect of harvesting time on yield attributes of cashew sprouts

Time of harvest	Total weight (g)	Length of plumule(cm)	Length of radicle(cm)	Length of cotyledon(cm)	Width of cotyledon(cm)	Weight of cotyledon (g)	Recovery of cotyledon(%)
T_1	5.83	3.79	6.72	5.83	2.55	3.94	68
T_2	6.05	4.72	7.68	5.89	2.29	4.06	67
T_3	6.15	6.18	7.50	6.38	2.51	3.83	62
T_4	5.78	8.53	7.30	5.94	2.52	2.91	51
SE(m)	0.297	0.287	0.326	0.14	0.056	0.239	2.2
SE(d)	0.420	0.406	0.462	0.197	0.079	0.338	3.0
CV (%)	12.217	9.886	10.957	5.686	4.542	15.876	8.516
CD @ 5%	NS	0.884	NS	0.412	0.173	0.705	6.3

T_1 – Cotyledon emergence stage T_2 – Cotyledon splitting stage T_3- Plumule emergence stage T_4- leaf unfurling stage
*Figures followed by the same alphabets do not differ significantly in DMRT

2018). Excessive sprout growth with later harvests of peanuts led to deteriorated eating and marketing quality (Lee et al., 2015). Harvesting of cashew sprouts at the leaf unfurling stage led to a low recovery of 51 per cent, in addition to an adverse effect of lower cotyledon weight (2.91g).

The harvesting time also had a significant effect on the quality of sprouts. The total sugars increased from 1.9 per cent at the cotyledon emergence stage to 2.3 per cent at the plumule emergence and leaf unfurling stage (Fig. 1). However, there was a distinct reduction in the total sugar content (2.48) as compared to the processed nut, which had a content of 7.17 per cent (Table 1). The polyphenol content ranged from 1.01 to 1.18 per cent. The polyphenol content was also highest (1.18%) at the cotyledon emergence stage. However, Adhikari et al. (2018) reported an increasing content of total polyphenols in peanut sprouts at later stages from day 5 to day 9, with higher contents recorded in sprouts without cotyledons.

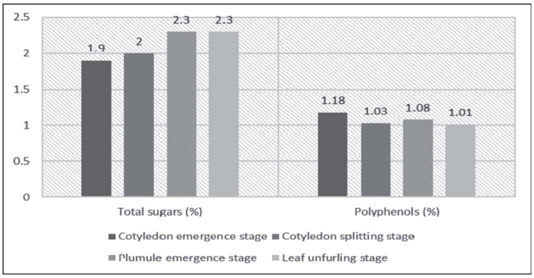

Figure 1. Effect of stage of harvest on total sugars and total polyphenol content of cashew sprouts

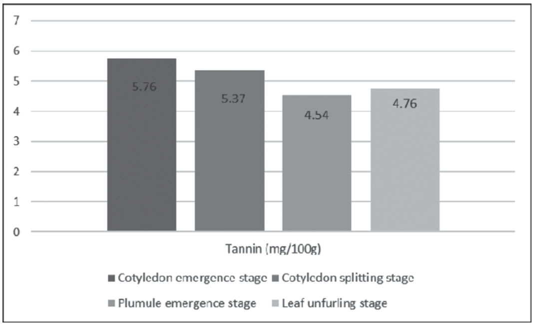

Figure 2. Effect of stage of harvest on tannin content of cashew sprouts

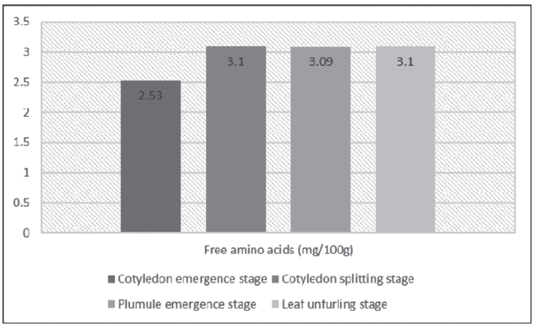

Figure 3. Effect of stage of harvest on free amino acid content of cashew sprouts

The highest tannin content of 5.76 per cent was recorded at the time of cotyledon emergence (Fig. 2). The lowest tannin content was recorded in cotyledons harvested at the plumule emergence stage (4.54 mg/100 g). The lowest free amino acid content of 2.53 mg/100g was recorded in cashew sprouts at cotyledon emergence stage (Fig. 3). A significant increment in the total free amino acid content of sprouted soybean varieties was reported by Martínez-Villaluenga et al. (2006), especially at the later stages of germination. The increase in free amino acid content could be due to the proteolysis of storage proteins during the early stages of seedling development (Lea and Joy, 1983).

Effect of pre-sowing treatments

Pre-sowing soaking has a significant effect on the germination percentage and mean germination time of cashew nuts (Table 3).

Longer soaking period in water and salt solution increased the germination percentage (Table 3). Similar results were reported by Menon et al. (2021). The time to the emergence of cashew sprouts was found to be the lowest when cashew nuts were pre-soaked in water for 24 or 36 hours (Oyewole and Koffa, 2010). Higher germination per cent was observed with soaking of nuts for 72 hours (95.3%) and 96 hours (90.3%) in water, with both treatments being at par. With salt solution, the highest germination of 86 per cent was obtained on soaking for 96 hours. Hydropriming and osmopriming have

Table 3. Effect of pre-sowing soaking on nut germination and sprout yield

Treatments	Germination (%) at 21 DAS	Mean germination time (days)	Yield of sprouted cotyledons(g 0.2m^{-2})
S_1- Control (no soaking)	51.30	14.7	327.25
S_2- 8 hours in water	57.00	14.3	329.17
S_3- 16 hours in water	59.67	12.2	350.54
S_4- 24 hours in water	71.00	10.8	446.41
S_5- 48 hours in water	87.00	9.9	553.47
S_6- 72 hours in water	95.30	8.6	544.10
S_7- 96 hours in water	90.30	8.9	542.00
S_8- 8 hours in 0.1% salt soln.	56.30	13.9	286.59
S_9- 16 hours in 0.1% salt soln.	57.00	11.9	349.12
S_{10}- 24 hours in 0.1% salt soln.	58.70	12.0	383.53
S_{11}- 48 hours in 0.1% salt soln.	75.70	9.1	414.27
S_{12}- 72 hours in 0.1% salt soln.	74.70	9.3	480.66
S_{13}- 96 hours in 0.1% salt soln.	86.70	8.7	533.00
SE(d)	0.02	0.61	6.80
SE(m)	0.02	0.43	4.81
CV (%)	5.04	6.81	1.95
CD @ 5%	0.06	1.27	13.98

*Figures followed by the same alphabets do not differ significantly in DMRT

been reported to increase protein synthesis and enzyme activity, leading to improved reserve mobilization (Wahid et al., 2008). Although the germination percentage was higher with hydropriming, the mean germination time was found to be lower on prolonged soaking both in water and salt solution. The germination percentage and mean germination time was high on prolonged soaking for 72 hours or 96 hours in water. Several workers have reported rapid and uniform emergence due to seed priming (Bruggink et al., 1999; Farooq et al., 2007; Janmohammadi et al., 2008). Longer period of soaking reduced the mean germination time, but the effects of soaking from 48 to 96 hours were at par. Similar observations were made by Basra et al. (2003), who reported that hydropriming of wheat seeds for 12 or 24 hours reduced the germination time as compared to 6 hours priming. Pre-soaking cashew nuts for 48, 72, and 96 hours resulted in the highest yields of cashew sprouts. Soaking in salt solution for 96 hours (S_{13}) gave a comparatively higher yield (533 g from 0.2 m^2).

Cashew sprouts are a novel food source having better nutritional qualities. In addition to consumption in the raw form, they also have the potential to be used in various products. Including sprouts in gourmet cooking and specialized nutrition would be an avenue of additional income for cashew farmers. Optimization of technology for sprout production could lead to commercialization on a large scale, as this area is attracting a lot of attention due to the easy and short production procedure.

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