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Standardization of Minimal Processing Treatments for Clove Basil and Sweet Basil Seeds

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Abstract

The seeds of clove basil (*Ocimum gratissimum*) and sweet basil (*O. basilicum*) are highly underutilized despite of their splendid nutritional composition and presence of bioactive constituents associated with several health benefits. The present investigation was carried out to enhance the organoleptic properties of seeds in an economical way through minimal processing treatments such as soaking, roasting and fermentation. The standardized minimal processing treatments for clove basil seeds included 4 h soaking, 3 min roasting at 105°C and 18 h fermentation with distilled water, curd, honey while for sweet basil seeds included 2 h soaking, 5 min roasting at 115°C and 30 h fermentation as same as clove basil. The processed basil seed powders prepared under these standardised conditions exhibited better sensorial acceptance than the unprocessed ones and can be efficiently utilised for development of novel nourishing convenience foods or enrichment of regularly consumed food products. Further, processing of basil seeds may enhance their utilisation in a similar way as that of basil leaves and in turn benefit the rural farming communities in generating additional income.

Keywords : *Ocimum* seeds, Soaking, Roasting, Fermentation, Sensory evaluation

The *Ocimum gratissimum* (clove basil, wild basil or shrubby basil) and *O. basilicum* (sweet basil, common basil or Indian basil) are the most important economical species cultivated in many parts of India especially for medicinal and culinary purposes. Presently a considerable interest has shifted towards medicinal seeds due to their rich phytochemistry and prophylactic properties. Basil seeds are considered as super seeds food of the present century, as consumption of these seeds helps in alleviating numerous diseases such as obesity, cardiovascular diseases, diabetes and cancers.

Basil seeds are tiny, aromatic and produces substantial amount of mucilage when soaked in water. The mucilage is tightly bound to the seed surface by columnar structures extended from the pericarp. The basil seeds being a potential source of dietary fiber, their consumption was associated with improved satiety and better management of body weight, blood glucose and cholesterol levels (Cherian, 2019). Further more, basil seeds possess good amounts of protein, minerals (calcium, magnesium, phosphorus, potassium, zinc, copper, manganese), essential fatty acids (α-linolenic acid, linoleic acid) and phenols, flavonoids, bioactive peptides with strong antioxidant, anticancer, antidiabetic, antiviral and antimicrobial activities (Khursheed *et al*., 2023).

Processing of mucilaginous seeds is mainly done to enhance their consumer acceptability and to develop novel convenience foods while retaining their nutritional value. It plays a vital role in promoting the food and nutrition security of nations in the modern world. Different techniques employed for minimal processing of seeds included soaking, boiling, steaming, pressure cooking, roasting, fermentation, germination. The minimal processing of seeds could help in enhancement of their nutrient bioavailability, bioactive properties, protein digestibility and lowering antinutrients in an economically feasible way. The processed seeds can be efficiently milled to develop shelf stable flours for utilization in development of wide range of value-added products.

Material and Methods

Procurement of Basil Seeds

The clove basil and sweet basil seeds were procured from local markets of Kadapa district, Andhra Pradesh, India. The seeds were cleaned manually, freed from broken seeds, other variety seeds and inert matter.

Standardization of Minimal Processing Treatments for Basil Seeds

The standardisation of minimal processing treatments *viz*. soaking, roasting and fermentation was done to develop powders with better organoleptic properties, which can be utilised for development of novel nourishing food products.

Soaking

The raw basil seeds were soaked in distilled water (1:40 w/v) for different time intervals *viz*. 2 h, 4 h, 6 h, 8 h, drained of excess water, dried at 60°C for 4 h, made into fine flours and subjected to sensory evaluation on nine-point hedonic scale (Meilgaard *et al*., 2016) for determination of better soaking duration (Afify *et al*., 2012) (Plates 1-4).

Roasting

The raw basil seeds (20g) were roasted in an open pan at three different temperatures cum time variations *viz*. 105°C for 3 min, 115°C for 5 min and 125°C for 7 min with continuous stirring. The seeds were cooled, made into fine powders and subjected for sensory evaluation to determine ideal roasting treatment (Arivuchudar and Nazni, 2020) (Plates 5-6).

Fermentation

Standardization of fermentation time for basil seeds: The raw basil seeds were allowed to ferment naturally with distilled water (1:80 w/v) at 37°C in a biological oxygen demand (BOD) incubator for different time durations *viz.,* 18 h, 24 h and 30 h for clove basil seeds and 30 h, 36 h and 42 h for sweet basil seeds. The fermentation of seeds was indicated by effervescence, liberation of heat and pH reduction of supernatant. The fermented seeds were drained of excess water, dried at 60°C for 4 h, made into fine powders and subjected for sensory evaluation to determine the ideal fermentation duration (Park *et al*., 2020).

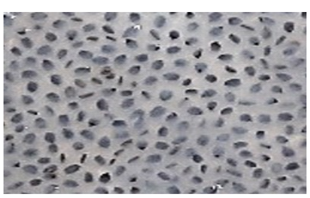


Plate 1 : Soaked clove basil seeds

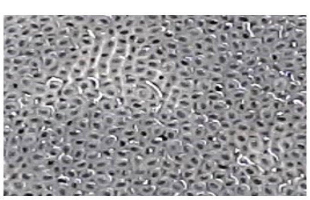


Plate 2 : Soaked sweet basil seeds

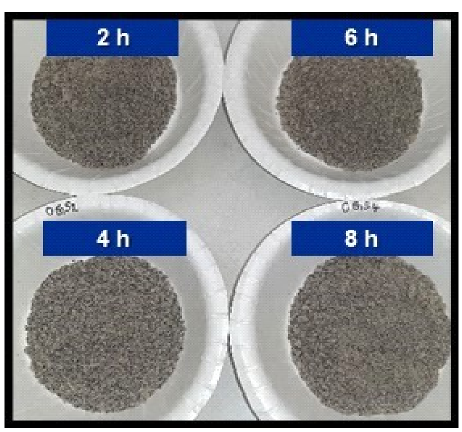


Plate 3 : Soaked clove basil seed powders

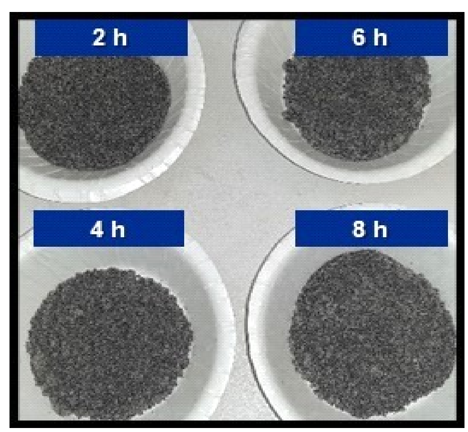


Plate 4 : Soaked sweet basil seed powders

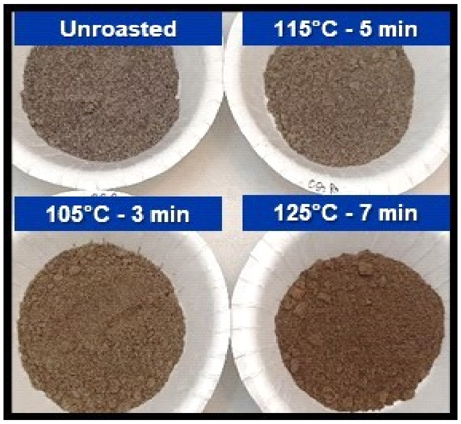


Plate 5: Roasted clove basil seed powders

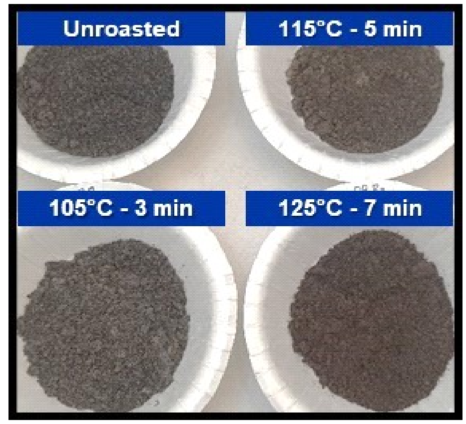


Plate 6: Roasted sweet basil seed powders

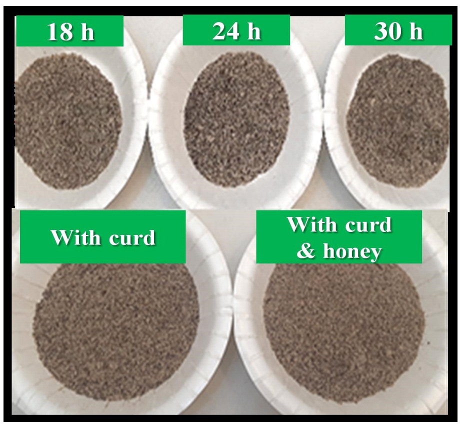


Plate 7 : Fermented clove basil seed powders

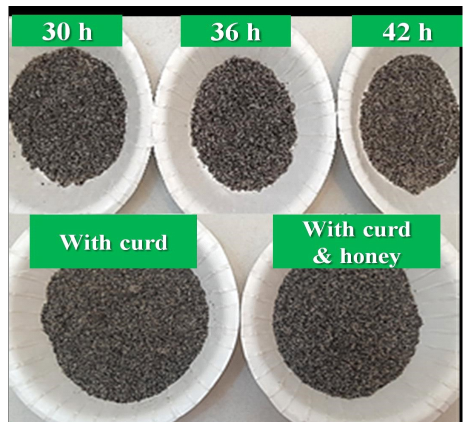


Plate 8 : Fermented sweet basil seed powders

Determination of ideal fermentation treatment for basil seeds : The raw basil seeds were allowed to ferment with distilled water (1:40 w/v), curd (1:3 w/w) and with or without honey (1:1 w/w) at 37°C in a BOD incubator for standardized duration. The ideal fermentation treatment was determined based on lactic acid bacterial population (Sarvani *et al*., 2020), total soluble solids (TSS) content, pH (Mashau *et al*., 2020), titratable acidity (AOAC, 2023) and sensory parameters of fermented basil seeds. For sensory evaluation, the fermented seeds were rinsed with distilled water, drained of excess water, dried at 60°C for 4 h and made into fine powders (Plates 7-8).

Results and Discussion

Soaking

Sensory properties played a vital role in the development of novel healthier foods in order to have consumer's acceptance. A semi-trained panel of thirty members evaluated the unprocessed and minimally processed basil seed powders. The sensory scores of unprocessed clove basil and sweet basil seed powders were 7.14, 6.95, 6.57, 6.57, 6.57 and 7.43, 7.43, 7.05, 7.05, 7.10 for appearance, texture, flavour, taste, overall acceptability respectively. The sweet basil seed powders exhibited better sensory attributes than clove basil seed powders due to characteristic sweet flavour and taste of sweet basil seeds. While the clove basil seeds exhibited subtly sweet flavour with slight bitterness and astringency similar to that of cloves and the powders were less accepted by panellists.

Soaking is the most common way basil seeds are consumed as a refreshing and nourishing food. The sensory scores obtained for 2 h, 4 h, 6 h and 8 h soaked clove basil and sweet basil seed powders are depicted in Fig. 1. The powders of 4 h-soaked clove basil seeds and 2 h-soaked sweet basil seeds exhibited

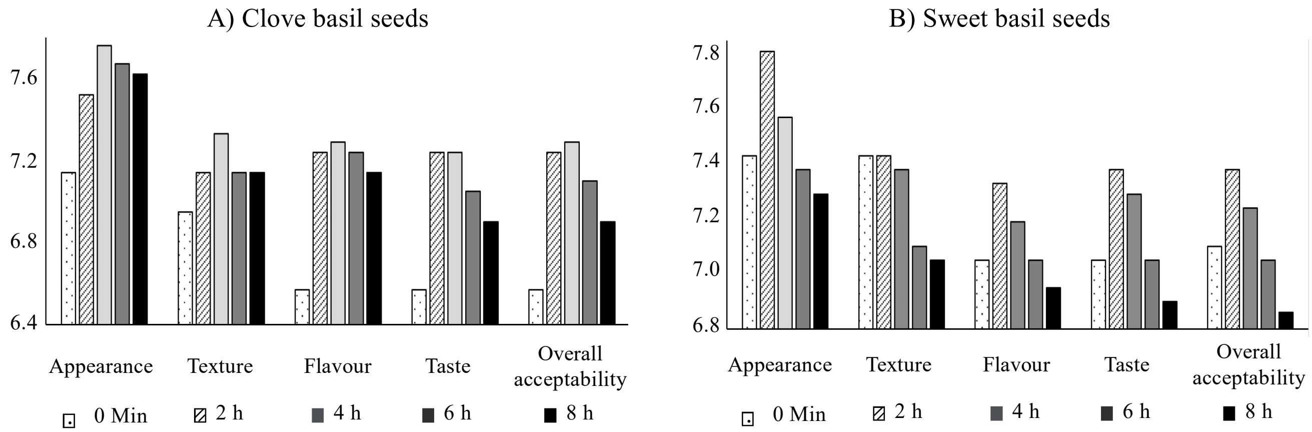


Fig. 1 : Sensory scores of soaked basil seed powders for different time intervals

Note : Data presented as mean of thirty determinations.

better sensorial acceptance with scores of 7.76, 7.33, 7.29, 7.24, 7.29 and 7.81, 7.43, 7.33, 7.38, 7.38 for appearance, texture, flavour, taste, overall acceptability respectively due to lighter colour imparted by the mucilage and decline in raw flavour and taste.

Prolonged soaking gradually declined the sensorial acceptance of both clove basil and sweet basil seed powders due to more mucilage formation that imparted gummy taste and oversoaked flavour. Likewise, Hawaldar and Ballal (2021) soaked the basil seeds for five different time periods *i.e.*, 30 min, 1 h, 4 h, 8 h, 12 h and noticed that seeds tend to absorb more water with increased soaking duration, making the ground paste more viscous concomitant with mucilage formation. Hence, soaking of clove basil seeds for 4 h and sweet basil seeds for 2 h was found to be ideal for the preparation of powders with better organoleptic properties.

The significant difference was observed between unsoaked and 4 h-soaked clove basil seed powders for all the sensory attributes. While there was significant difference only in the taste of unsoaked and 2 h soaked sweet basil seed powders. Among the better accepted powders of soaked clove basil seeds and sweet basil seeds, the sweet basil seed powder exhibited better sensory scores might be due to lesser duration of soaking.

Roasting

Roasting is a simple, accessible process, usually done at higher temperatures (150-400°C) for shorter duration to promote various chemical reactions crucial for the development of pleasant colour, taste, flavour and oxidative stability of seeds. Further, it promoted the inactivation of enzymes, microbes and destruction of toxins, pollutants in seeds. Goszkiewicz *et al.* (2020) noticed significant difference in colour, aroma, taste and crispiness of unroasted and roasted sunflower seeds. Due to significant effect of roasting temperature and duration on the organoleptic properties, it is essential to determine the ideal temperature and time for roasting of each seed (Nikzadeh and Sedaghat, 2008).

The sensory scores obtained for 105°C - 3 min, 115°C - 5 min and 125°C - 7 min roasted clove basil and sweet basil seed powders are depicted in Fig. 2. The roasting of basil seeds improved the sensory attributes of powders till 105°C - 3 min for clove basil seeds and till 115°C - 5 min for sweet basil seeds and thereafter deteriorated sensorial acceptance with increase in roasting temperature cum duration due to charring of seeds that imparted burnt flavour and taste. Similarly, Arivuchudar and Nazni (2020) roasted the sweet basil seeds at 115°C for 6 to 8 minutes, beyond which resulted in charring while <115°C did not bring any significant change in colour and aroma of seeds.

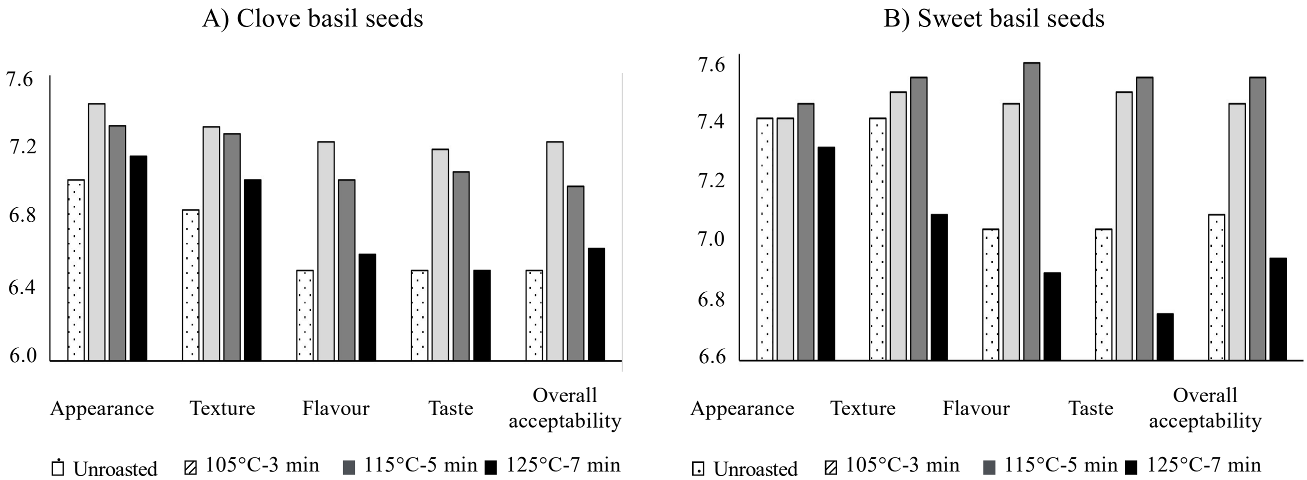


Fig. 2 : Sensory scores of roasted basil seed powders for different temperature cum time variations

Note : Data presented as mean of thirty determinations.

The powders of 105°C - 3 min roasted clove basil seeds and 115°C - 5 min roasted sweet basil seeds exhibited better sensorial acceptance with scores of 7.62, 7.48, 7.38, 7.33, 7.38 and 7.48, 7.57, 7.62, 7.57, 7.57 for appearance, texture, flavour, taste, overall acceptability respectively on nine-point hedonic scale. This was due to reduced mucilage content, increased crispiness of seeds that resulted in fine powders and nice roasted colour, aroma and flavour of powders. Hence, roasting of clove basil seeds at 105°C for 3 min and sweet basil seeds at 115°C for 5 min was found to be ideal for the preparation of powders with better organoleptic properties.

The significant difference was observed between unroasted and 105°C - 3 min roasted clove basil seed powders for all the sensory attributes. While there was significant difference in the taste, flavour and overall acceptability of unroasted and 115°C - 5 min roasted sweet basil seed powders. Among the better accepted powders of roasted clove basil seeds and sweet basil seeds, the sweet basil seed powder exhibited better sensory scores except for appearance due to lumping resulted from high fat content.

Fermentation

Fermentation is a desirable biochemical process in which the primary food matrix was altered by the microorganisms and their enzymes. Lactic acid fermentation was found to be beneficial in inhibiting the growth of pathogenic microbes and extending the shelf life of foods (Deepa *et al*., 2016). Further, it enhanced the bioaccessibility, bioavailability of nutrients and improved the functionality, organoleptic properties of foods (Nkhata *et al*., 2018).

Standardization of Fermentation Time for Basil Seeds

The incubation time appeared to be crucial variable that significantly influenced the sensory attributes of fermented seeds (Galand *et al*., 2021). The sensory scores obtained for 18 h, 24 h, 30 h fermented clove basil seed and 30 h, 36 h, 42 h fermented sweet basil seed powders are depicted in Fig. 3.

The 18 h fermented clove basil seeds and 30 h fermented sweet basil seed powders exhibited better sensorial acceptance with scores of 7.57, 7.29, 7.24, 7.19, 7.19 and 7.38, 7.33, 7.29, 7.24, 7.24 for appearance, texture, flavour, taste, overall acceptability respectively. However, rise in fermentation duration gradually declined the organoleptic acceptability of both clove basil and sweet basil seed powders due to development of musty flavour and over fermented taste. Hence, fermentation of clove basil seeds for 18 h and sweet basil seeds for

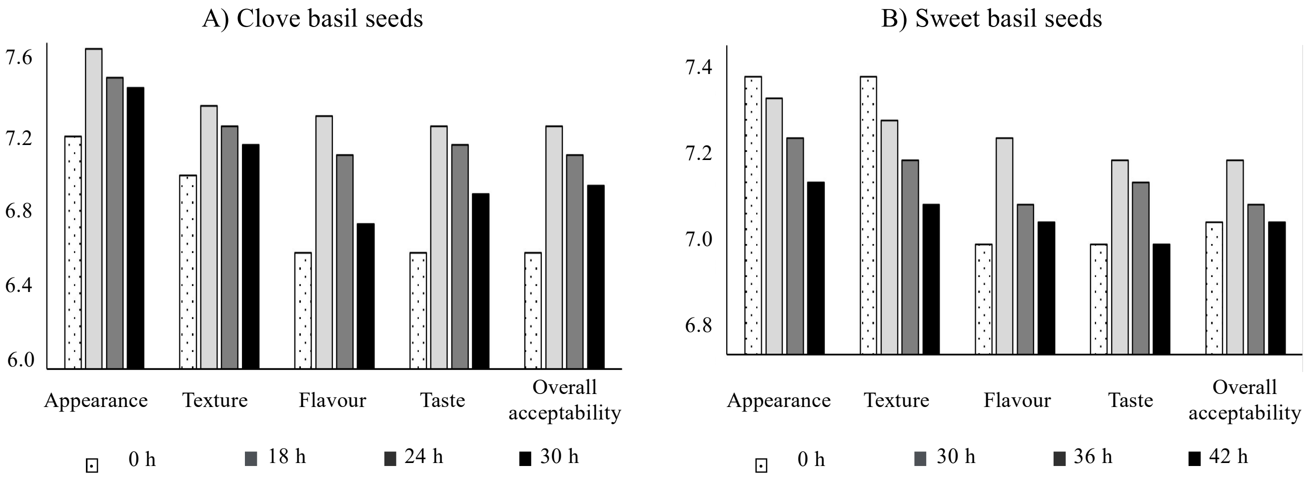


Fig. 3 : Sensory scores of fermented basil seed powders for different incubation times

Note : Data presented as mean of thirty determinations.

30 h was found to be ideal for the preparation of powders with better organoleptic properties.

However, there was no significant difference in the texture of powders made from non-fermented and fermented clove basil seeds for different time intervals. While there was no significant difference in all the sensory attributes of powders made from non-fermented and fermented sweet basil seeds for different durations. Among the better accepted powders of fermented clove basil seeds and sweet basil seeds, the sweet basil seed powder exhibited better sensory scores except for appearance due to characteristic black colour which was liked less by panellists.

Determination of Ideal Fermentation Treatment for Basil Seeds

Lactic Acid Bacterial Population of Fermented Basil Seeds

The lactic acid bacterial population of non-fermented and fermented basil seeds with different treatments for standardized duration is presented in Table 1. The fermentation of clove basil seeds and sweet basil seeds with distilled water alone improved the lactic acid bacterial population from 99.5 to 26.5×10^5 CFU/g and from 110.0 to 17.0×10^6 CFU/g respectively. While the fermentation of clove basil seeds and sweet basil seeds with distilled water and curd improved the lactic acid bacterial populations to 66.5×10^5 CFU/g and 44.5×10^6 CFU/g respectively. Balamurugan *et al*. (2014) depicted that the home-made curds possessed wide spectrum of lactic acid bacteria with a potential to exert probiotic effects. Hence, fermentation of basil seeds in combination with curd resulted in better lactic acid bacterial population.

Further, the fermentation of clove basil seeds and sweet basil seeds with distilled water, curd and honey was found to be more ideal as it greatly improved the lactic acid bacterial populations to 297.0×10^5 CFU/g and 76.0×10^6 CFU/g respectively. The curd served as a natural sink of lactic acid bacteria and honey as a prebiotic aiding in better fermentation of seeds in shorter duration. Mohan *et al*. (2020) showed that honey sweetened yoghurt possessed significantly higher probiotic population than the unsweetened yoghurt along with higher amounts of lactic and propionic acids. Thus, the combination of yoghurt and honey could serve as a potential synbiotic *i.e.*, synergistic combination of probiotic and their prebiotic substrates.

The fermentation of clove basil seeds and sweet basil seeds in combination with curd and honey resulted in significantly higher lactic acid bacterial population compared to all other treatments employed. There was significant difference between the non-fermented and fermented basil seeds with different treatments for

TABLE 1

Lactic acid bacterial population of fermented basil seeds with different treatments

Seeds	Treatment	CFU/g					
		10^1	10^2	10^3	10^4	10^5	10^6
Clove basil	Non-fermented	99.50 ± 2.12	10.00 ± 1.41	0.00 ± 0.00	0.00 ± 0.00	0.00 [a] ± 0.00	0.00 [a] ± 0.00
	Fermented with distilled water for 18 h	Lawn	Lawn	Lawn	267.00 ± 2.83	26.50 [b] ± 0.71	2.50 [ab] ± 0.71
	Fermented with distilled water + curd for 18 h	Lawn	Lawn	Lawn	Lawn	66.50 [c] ± 2.12	6.50 [b] ± 0.71
	Fermented with distilled water + curd + honey for 18 h	Lawn	Lawn	Lawn	Lawn	297.00 [d] ± 1.41	27.50 [c] ± 2.12
	CD at 1%	-	-	-	-	6.09	5.40
Sweet basil	Non-fermented	110.00 ± 2.83	11.00 ± 1.41	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 [a] ± 0.00
	Fermented with distilled water for 30 h	Lawn	Lawn	Lawn	Lawn	170.00 ± 2.83	17.00 [b] ± 1.41
	Fermented with distilled water + curd for 30 h	Lawn	Lawn	Lawn	Lawn	467.00 ± 2.83	44.50 [c] ± 2.12
	Fermented with distilled water + curd + honey for 30 h	Lawn	Lawn	Lawn	Lawn	Lawn	76.00 [d] ± 2.83
	CD at 1%	-	-	-	-	-	8.77

Note :Values expressed as mean ± standard deviation of two determinations. Means within the same column followed by common superscript do not differ significantly at p ≤ 0.01. CFU: Colony forming units, CD: Critical difference.

lactic acid bacterial population. The sweet basil seeds exhibited better lactic acid bacterial population than the clove basil seeds might be due to more duration of fermentation.

pH, Titratable Acidity and Total Soluble Solids Content of Fermented Basil Seeds

The pH, titratable acidity and total soluble solids (TSS) content of non-fermented and fermented seeds of clove basil and sweet basil with different treatments for standardized duration are as presented in Table 2. Both the non-fermented and fermented clove basil seeds exhibited significantly lower pH and higher titratable acidity, TSS content compared to sweet basil seeds. The interaction between seed variety and fermentation treatment significantly influenced the pH, titratable acidity and TSS content of basil seeds.

The non-fermented clove basil seeds and sweet basil seeds exhibited pH of 6.39 and 6.67, titratable acidity of 0.09 and 0.08 per cent lactic acid, TSS content of 0.99 and 0.80° Brix respectively.

Fermentation of clove basil seeds and sweet basil seeds with different treatments resulted in significant decline in pH and increment in titratable acidity due to accumulation of organic acids produced by fermenting microorganisms. Further, there was significant increment in the TSS of seeds with fermentation due to release of sugars and other carbohydrates related compounds by fermenting microbiota at higher rate than the rate of their utilization. Similar trends in pH, titratable acidity and TSS were reported by Yousif and Tinay (2001), Adebo *et al.* (2021) during natural lactic acid fermentation of grains at 37°C.

TABLE 2

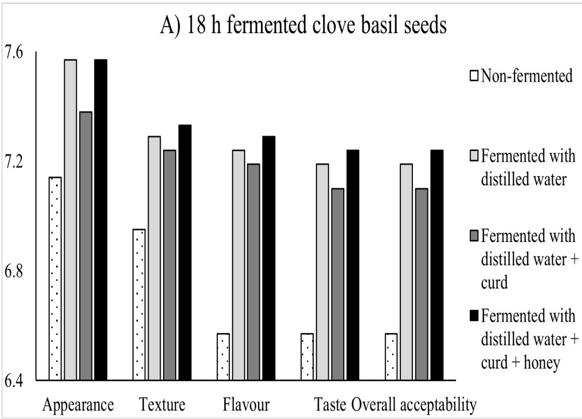
Titratable acidity, pH and total soluble solids content of fermented basil seeds

Seeds	Treatment	pH		Titratable acidity (% lactic acid)		TSS (°Brix)	
Clove basil	Non-fermented	6.39 ± 0.01		0.09 ± 0.00		0.99 ± 0.01	
	Fermented with distilled water for 18 h	5.87 ± 0.01		1.41 ± 0.05		3.50 ± 0.01	
	Fermented with distilled water + curd for 18 h	5.18 ± 0.01		2.49 ± 0.05		4.47 ± 0.01	
	Fermented with distilled water + curd + honey for 18 h	4.88 ± 0.01		3.95 ± 0.02		5.72 ± 0.01	
Sweet basil	Non-fermented	6.67 ± 0.01		0.08 ± 0.01		0.80 ± 0.01	
	Fermented with distilled water for 30 h	6.09 ± 0.01		1.32 ± 0.05		1.49 ± 0.01	
	Fermented with distilled water + curd for 30 h	5.23 ± 0.01		2.37 ± 0.05		2.87 ± 0.01	
	Fermented with distilled water + curd + honey for 30 h	4.97 ± 0.01		3.89 ± 0.03		4.82 ± 0.01	
	Mean	5.68		1.95		3.05	
	SE_m	0.01		0.01		0.04	
		F value	CD at 1%	F value	CD at 1%	F value	CD at 1%
Seed variety		*	0.01	*	0.04	*	0.01
Fermentation treatment		*	0.02	*	0.06	*	0.02
Seed variety × Fermentation treatment		*	0.03	*	0.08	*	0.02

Note: Values presented as mean ± standard deviation of three determinations. *Significant difference at $p \leq 0.01$. TSS: Total soluble solids, SEm: Standard error of mean, CD: Critical difference.

Fermentation with distilled water alone decreased the pH of clove basil seeds and sweet basil seeds to 5.87 and 6.09 respectively. It has improved the titratable acidity to 1.41 and 1.32 per cent lactic acid and TSS content to 3.50° Brix and 1.49° Brix respectively for clove basil seeds and sweet basil seeds. Fermentation in combination with curd resulted in better decline in pH to 5.18 and 5.23 and increment in titratable acidity to 2.49 and 2.37 per cent lactic acid respectively for clove basil seeds and sweet basil seeds due to increased lactic acid bacterial population which promoted synthesis of organic acids such as lactic acid. Further, there was substantial increment in TSS content of clove basil seeds and sweet basil seeds to 4.47° Brix and 2.87° Brix respectively.

Among all the treatments employed, fermentation of basil seeds with distilled water, curd and honey was found to ideal to achieve higher degree of fermentation in a shorter duration. It had remarkably reduced the pH and improved the titratable acidity, TSS content of clove basil seeds to 4.88, 3.95 per cent lactic acid, 5.72° Brix respectively and of sweet basil seeds to 4.97, 3.89 per cent lactic acid, 4.82° Brix respectively indicating highly significant lactic acid fermentation compared to other treatments. The significant increment in TSS content was also due to addition of



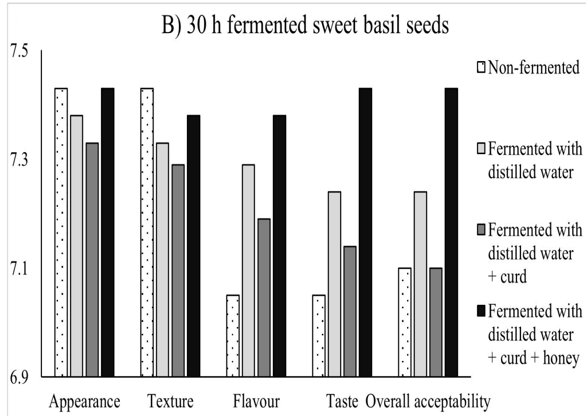


Fig. 4 : Sensory scores of fermented basil seed powders with different treatments

Note : Data presented as mean of thirty determinations.

honey along with abundance of soluble sugars produced upon fermentation.

Sensory Parameters of Fermented Basil Seed Powders

The obtained sensory scores for powders made from basil seeds fermented with different treatments for standardized duration are as depicted in Fig. 4. Findings revealed that the powders made from clove basil seeds and sweet basil seeds fermented with distilled water, curd and honey exhibited better sensorial acceptance than other treatments with scores of 7.57, 7.33, 7.29, 7.24, 7.24 and 7.43, 7.38, 7.38, 7.43, 7.43 for appearance, texture, flavour, taste, overall acceptability respectively on hedonic scale. This was due to reduction in fermented flavour and the sweet taste imparted by honey. Honey acted as a natural sweetener, decreased the sourness of acidic foods such as yoghurt and increased their consumer acceptability (Varga, 2006).

The significant difference was observed between the powders made from non-fermented and fermented clove basil seeds with distilled water, curd and honey for all the sensory attributes. However, significant difference between the powders made from non-fermented and fermented sweet basil seeds with distilled water, curd and honey was noticed only for the taste. Among the powders made from clove basil seeds and sweet basil seeds fermented with distilled water, curd and honey, the sweet basil seed powder exhibited better sensory scores except for appearance.

Hence, fermentation of clove basil seeds and sweet basil seeds with distilled water, curd and honey for standardized duration was found to be ideal for better lactic acid bacterial population, titratable acidity, total soluble solids content and lower pH which reflects greater degree of fermentation and for preparation of powders with better organoleptic properties.

Pearson Correlation Between Fermentation Parameters of Basil Seeds

The relationship between the fermentation parameters of basil seeds was determined using Pearson's correlation coefficient (r) (Table 3). The lactic acid bacterial population was significantly correlated with the titratable acidity (r = 0.9930) and TSS content (r = 0.9974) of fermented sweet basil seeds at one per cent level. Adebo *et al*. (2021) reported that the increment in titratable acidity and TSS was attributed to the rise in enzymatic activities of fermenting microbes which promoted production of organic acids and simple sugars.

The pH of fermented clove basil seeds and sweet basil seeds was negatively correlated with titratable acidity with r = -0.9816 and -0.9529 respectively which was significant at five per cent level. Similarly, Adebo *et al*. (2018) reported significant negative correlation

TABLE 3

Pearson correlation coefficient between the fermentation parameters of basil seeds

A)Clove basil seeds

	LB	pH	TA	TSS	App.	Texture	Flavour	Taste	OA
LB	1.0000	-0.8213	0.9025	0.8083	0.5766	0.6108	0.5622	0.5848	0.5848
pH		1.0000	-0.9816 *	-0.9711 *	-0.6535	-0.8053	-0.8092	-0.7947	-0.7947
TA			1.0000	0.9776 *	0.7203	0.8277	0.8138	0.8130	0.8130
TSS				1.0000	0.8153	0.9199	0.9156	0.9112	0.9112
App.					1.0000	0.9618 *	0.9379	0.9596 *	0.9596 *
Texture						1.0000	0.9955 **	0.9994 ***	0.9994 ***
Flavour							1.0000	0.9974 **	0.9974 **
Taste								1.0000	1.0000 ***
OA									1.0000

B) Sweet basil seeds

	LB	pH	TA	TSS	App.	Texture	Flavour	Taste	OA
LB	1.0000	-0.9444	0.9930 **	0.9974 **	-0.0184	-0.2812	0.7824	0.8320	0.7336
pH		1.0000	-0.9529 *	-0.9201	0.3452	0.5633	-0.7092	-0.6818	-0.5218
TA			1.0000	0.9842 *	“0.0719	-0.3554	0.8398	0.8613	0.7522
TSS				1.0000	0.0501	-0.2112	0.7687	0.8378	0.7538
App.					1.0000	0.9311	0.0308	0.2670	0.4734
Texture						1.0000	-0.3344	-0.0926	0.1255
Flavour							1.0000	0.9603 *	0.8904
Taste								1.0000	0.9742 *
OA									1.0000

Note: *Significant at $p \leq 0.05$ (two-tailed), **Significant at $p \leq 0.01$ (two-tailed), ***Significant at $p \leq 0.001$ (two-tailed). LB: Lactic acid bacterial population, TA: Titratable acidity, TSS: Total soluble solids, App.: Appearance, OA: Overall acceptability.

between pH and titratable acidity of ting made from fermentation of sorghum for different durations. This was due to production of organic acids which lowered pH and improved titratable acidity of ting with the increment in fermentation duration. A significant correlation was also observed between the titratable acidity and TSS content with r = 0.9776 for clove basil seeds and r = 0.9842 for sweet basil seeds might be due to simultaneous increment in both the parameters upon fermentation.

The overall acceptability of fermented clove basil seed powder was significantly correlated with its appearance (r = 0.9596), texture (r = 0.9994), flavour (r = 0.9974) and taste (r = 1.0000). However, for fermented sweet basil seed powder significant correlation was noticed only between the flavour and taste (r = 0.9603), taste and overall acceptability (r = 0.9742). Thus, significant correlation was observed between the various sensory attributes of fermented basil seed powders.

The standardized minimal processing treatments for better sensorial acceptance of clove basil seed powders included 4 h soaking, 3 min roasting at 105° C and 18 h fermentation with distilled water, curd, honey.

While for sweet basil seed powders included 2 h soaking, 5 min roasting at 115°C and 30 h fermentation with distilled water, curd, honey. These processed basil seed powders with improved sensorial acceptability compared to unprocessed ones can be efficiently utilised for development of wide range of value-added food products. Processing may enhance the utilisation of basil seeds in a similar way as that of basil leaves and in turn benefit the rural farming communities in generating additional income.

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