



Study on Quality Characteristics and Nutraceutical Properties of Paneer Fortified with Ashwagandha (*Withania somnifera*) Powder

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ABSTRACT

Background: Ashwagandha (*withania somnifera*) has considerable importance in the history of Ayurveda. Its therapeutic importance is well known and so the present study was carried out to develop paneer fortified with ashwagandha and analyze its quality parameters and nutraceutical properties.

Methods: Trails were carried out to optimize the different concentrations of ashwagandha addition like 0.2%, 0.4%, 0.6%, 0.8% and 1.5% at different stages. Then, samples were prepared with full cream, toned and cow milk for developing the ashwagandha fortified paneer. The Physico-chemical, Textural, Anti-oxidative and Microbial analysis was done and compared with market paneer as a control sample.

Result: Results revealed that the addition of 0.4% ashwagandha before heat treatment of milk was found to have the most sensory acceptance. It was inferred from the analysis that full cream milk paneer (FCMP) fortified with 0.4% ashwagandha was found to be more highly acceptable than other fortified paneer variants. All paneer samples evaluated were of good quality and had less microbial load.

Key words: Ashwagandha, Microbes, Milk variants, Paneer, Physico-chemical, Textural.

INTRODUCTION

Milk is often recognized as nature's most comprehensive food. Milk serves as a rich supply of fat, protein, lactose, vitamins and minerals (Kumar *et al.*, 2020). About 55% of milk is utilized to make products and from that 40% is used to make traditional dairy products, including 7% in paneer and chhana (Rao, 2020).

Paneer is a widely consumed Indian dairy product that is made by coagulating milk using heat and acid, similar to cottage cheese (Singh *et al.*, 2015). Paneer typically contains the protein and most of the salts and colloidal elements, lactose, milk proteins, soluble lipids, vitamins and other milk components. It is commercially accessible at a lesser cost and is an excellent source of animal protein for consumers. Paneer is a good source of minerals like calcium and phosphorus, as well as vitamins and lipids, with a biological value ranging from 80 to 86 (Kumar *et al.*, 2020).

Although paneer is well favoured, its limited durability has consistently posed an issue as it tends to lose its freshness within just 2-3 days. Paneer spoiling is mostly caused by bacterial proliferation, which induces numerous physicochemical alterations that lead to undesirable flavour production (Eresam *et al.*, 2015). In recent years, various preservation methods have been employed to prolong the shelf life of paneer, such as preservatives, packaging, thermal processing and low-temperature storage. However, these techniques were expensive or had some harmful health effects. Spices and herbs possess a renowned capability to inhibit the growth of microorganisms in food,

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thereby acting as a preservative (Khatkar *et al.*, 2017). In the given context, Ashwagandha (*Withania somnifera*) is a significant botanical remedy renowned for its antimicrobial, aromatic and gustatory attributes (Singla *et al.*, 2017). It is a member of the Solanaceae family, which has been utilized for its therapeutic properties in traditional medical systems such as Ayurveda, Unani and Siddha for over 5000 years (Mandlik and Namdeo, 2021). The plant's proven health benefits are attributable to its abundance of phytochemical

compounds, including steroidal lactones (withanolides, withaferins), steroidal alkaloids, saponins, flavonoids, phenols, carbohydrates, glycosides, phytosterols, terpenoids and others (Swaminathan and Santhi, 2019). Previous studies have documented the numerous advantageous health properties of *W.somnifera*, including antioxidant, antimicrobial, immunomodulatory, anti-inflammatory, anticancer, adaptogenic and cardioprotective (Chaturvedi *et al.*, 2018; Narayana *et al.*, 2022).

The functional relationship between this ashwagandha powder and paneer has not been investigated; thus, the current study was conducted to establish ashwagandha added paneer with significant therapeutic value and to determine the enhanced quality attributes and nutraceutical properties.

MATERIALS AND METHODS

The ashwagandha powder and the different milk variants used for the study were procured from the local markets of Varanasi. The study was carried out in the laboratory of the Department of Dairy Science and Food Technology, Banaras Hindu University, Varanasi with appropriate methods and all the reagents used were of analysis standards and HPLC grade.

Optimization of stage of ashwagandha addition

Initially, the stage of powder addition was optimized by adding ashwagandha powder (toned milk was used) at different stages by following the process by Bhattacharya *et al.* (1971).

Stage 1: Before heat treatment of milk (Fig 1).

Stage 2: After heat treatment but before coagulant addition (Fig 2).

Preparation of paneer samples for sensory analysis

T₁ (0.2%), T₂ (0.4%), T₃ (0.6%), T₄ (0.8%) and T₅ (1.5%) were the five samples with different concentrations of ashwagandha

powder and market paneer was used as a control. A semi-trained panel of judges used a 9-point Hedonic scale to assess the sensory quality of ashwagandha-fortified paneer samples. Colour and appearance, body and texture, flavor, mouthfeel and overall acceptance all require a numerical number. Based on the sensory assessment results, the optimal concentration of ashwagandha addition was chosen and employed in the final experimental trial.

Preparation of ashwagandha-fortified paneer

The paneer was made in three different milk samples. Thus, three variants of ashwagandha incorporated paneer was developed. FCMP (Full cream milk paneer), TMP (Toned milk paneer) and CMP (Cow milk paneer) (Fig 3).

Proximate analysis

Paneer samples were analyzed for their proximate composition through prescribed procedures with necessary changes. Moisture (AOAC, 2000), Total solids (Neethu and Sneha, 2020), Fat (IS: 1224, Part-2 1977), Protein (IS: 1479, Part II 1961), Ash (IS: SP: 18, part II 1981), Acidity (IS: 1479, part II 1960) and Free Fatty Acid (%Oleic acid) (Sehgal, 2016).

Antioxidant content

The % DPPH scavenging activity of ashwagandha powder sample was estimated by following the protocol as described by Hatami *et al.* (2014) with slight modification. 4 mg of DPPH was dissolved in 10 ml of HPLC grade methanol. 1 g of sample and 10 ml methanol was taken for centrifugation at 6000 rpm/min. The supernatant was again centrifuged at 10000 rpm/10 min. 5 ml of the centrifuged supernatant and 1 ml DPPH solution was mixed and kept for incubation (37°C) for 30min. A blank (5 ml methanol and 1 ml DPPH solution) was used for comparison. The absorbance of the resulting solutions was measured by using the spectrophotometer (Shimadzu UV-1800, JAPAN)



Fig 1: Addition of ashwagandha before heat treatment of milk.



Fig 2: Addition of ashwagandha before addition of coagulant.

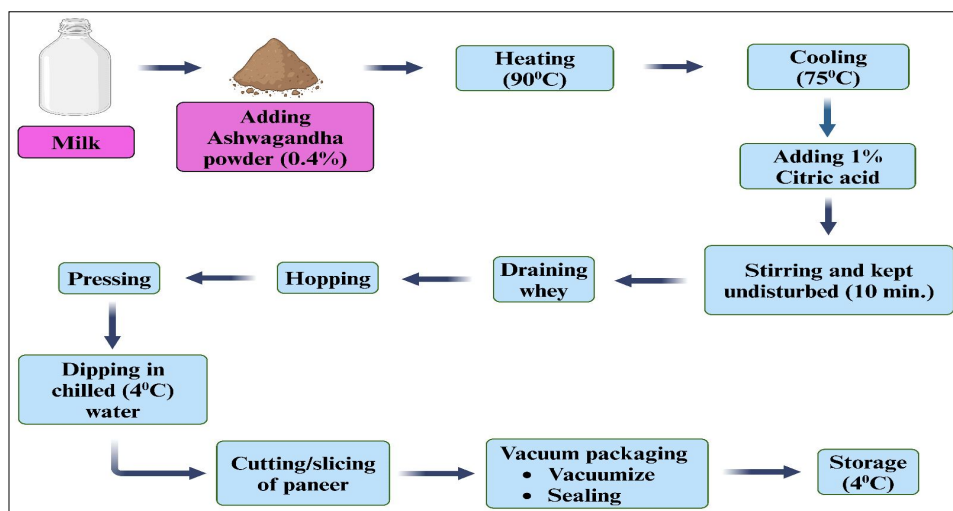


Fig 3: Flow chart for preparation of ashwagandha incorporated paneer.

at 517 nm. The Folin-Ciocalteu method was used to calculate TPC. 0.5 ml of the sample extract was taken in a test tube and 2.5 ml of diluted Folin-Ciocalteu Reagent (FCR) (1ml FCR in 9 ml distilled water) was added followed by 1 ml of 7.5% Na_2CO_3 and then kept for an incubation for 1 hour at room temperature. The absorbance of the resulting solutions was measured using a spectrophotometer (Shimadzu UV-1800, JAPAN) at 760 nm wavelength. A calibration curve was created using gallic acid as the standard at concentrations ranging from 50 to 500 $\mu\text{g/mL}$. Gallic Acid Equivalents (GAE) are commonly used to express TPC content (Miniati, 2007).

Texture profile analysis (TPA)

The textural analysis of paneer sample was done using texture analyser (The Brookfield CT3 Texture Analyzer, USA). TPA parameters, such as hardness, cohesiveness, springiness, adhesiveness and chewiness were determined. A probe TA18 was attached to the crosshead of the machine. The instrument test settings were as

follows: option: return to start; test mode: TPA; pre-test speed: 2 mm/sec; test speed: 2 mm/sec; post-test speed: 2 mm/sec; distance: 10 mm; trigger force: 5 g, probe: TA18 probe. The paneer samples were cut into $2 \times 2 \times 2$ cm cubes and were tempered to 25°C in a temperature-controlled cabinet for 1-2 h and the tests were carried out at the same temperature. The probe was positioned centrally over the sample surface and allowed to penetrate the product twice (1st and 2nd bite) for generating a force-time curve.

Microbial analysis

The standard plate counts (cfu/g) of paneer samples were evaluated by using method described in IS: 5402 (1969). One g of paneer sample aseptically weighed and transferred into a sterile 9 ml dilution blank (phosphate buffer) and mixed well (10^{-1} dilution). 1 ml solution then was added into 9 ml buffer (10^{-2} dilution). Same process was followed till 10^{-3} dilution. Then the standard plate count agar media was poured into petri plates and allowed to

solidify. After adding 1 ml of each dilution (duplicate) the solidified plates were incubated at 37°C for 48 hrs. in an incubator (Remi Elektrokinetik, India) and the number of colonies developed was recorded.

The coliform count was evaluated by using method given IS: 5401 (1969). The serial dilutions prepared for standard plate count were used for coliform count. 1 ml from each was taken in duplicate in violet red bile agar (VRBA) media petri plates was added. The plate was again overlaid with VRBA media and allowed to solidify. Then the plates were incubated at 37°C for 24 hrs. in an incubator. The number of coliform colonies was recorded as cfu/g.

The yeast and mold count of paneer samples was determined by using method described in IS: 5403 (1969). The serial dilutions prepared for standard plate count were used for enumeration of yeast and mold count. Petri plates with potato dextrose agar (PDA) were used by adjusting the pH by 10% tartaric acid solution. After solidification 1ml of dilutions were added in resp. plates in duplicates, then plates were incubated at 25°C for 5 days. At the end of incubation period count of the colonies of yeast and mold count were recorded as cfu/g.

Statistical analysis

For the present investigation, the data was analyzed with various statistical tools such as mean and standard error and ANOVA.

RESULTS AND DISCUSSION

Initially, the stage of ashwagandha addition was optimized and it was determined that adding the powder before heating of milk was satisfactory (Table 1). Ashwagandha powder was incorporated and subjected to sensory evaluation in various concentrations of 0.2%, 0.4%, 0.6%, 0.8% and 1.5%.

Sensory analysis

On analysis of paneer samples, it was observed that the highest and lowest scores for different parameters were found for different samples (Table 2). For color and appearances, the maximum value was observed in T₂ and the minimum in T₅. A similar result was found in turmeric-fortified paneer (Chandrakant, 2021). For body and texture, T₀, T₁ and T₂ had the same score and minimum for T₅ because of its hard body and texture. For flavor, T₂ had a higher score as compared to other samples. As a result, an increase in the concentration of ashwagandha powder in the paneer can result in a decrease in the acceptability of the paneer. T₂ had the highest score for mouthfeel whereas T₅ had the least. It is also mentioned that ashwagandha powder has a potent flavor; as a result, a higher concentration can have a negative impact on mouthfeel.

From the overall analysis, T₂ (8.37±0.25) received a higher overall acceptability rating. The body and texture of T₂ were found to be similar to that of the control sample and with 0.4% addition, ashwagandha's mildly bitter flavor did not overpower the paneer sample. The optimized product was studied in three milk variants, full cream, toned and cow milk.

Physico-chemical analysis of paneer

Moisture

According to BIS standards, the moisture of the paneer should be a maximum of 60% and the above samples meet the requirement. The highest content was observed for the control sample (51.42±0.20%) and the lowest was observed for FCMP (47.53±0.22%) (p<0.05) (Table 3). The incorporation of ashwagandha powder has reduced the moisture content of paneer significantly. Modi *et al.* (2023) studied the effect of ashwagandha incorporation on

Table 1: Sensory analysis of ashwagandha added paneer samples added at different stages.

Parameters	Stage 1	Stage 2	SEM	CD 1%	CV	SED
Colour and appearance	7.68±0.37	6.23±0.4	0.048	0.187	1.184	0.067
Body and texture	7.57±0.24	6.43±0.37	0.251	0.696	4.282	0.177
Flavor	8.43±0.24	7.09±0.25	0.157	0.615	3.498	0.222
Mouthfeel	7.49±0.12	6.41±0.17	0.113	0.445	2.824	0.160
Overall acceptability	7.89±0.31	6.93±0.23	0.202	0.795	4.730	0.286

n=3; Significant difference (p<0.05).

Table 2: Sensory evaluation of paneer samples.

Parameters	T ₀ (Control)	T ₁ (0.2%)	T ₂ (0.4%)	T ₃ (0.6%)	T ₄ (0.8%)	T ₅ (1.5%)	SEM	CD 1%	CV	SED
Colour and appearance	7.12±0.25	7.50±0.40	8.12±0.25	7.12±0.25	7.12±0.25	6.50±0.40	0.128	0.393	3.049	0.18
Body and texture	8.25±0.28	8.25±0.28	8.25±0.28	8.12±0.25	7.50±0.40	6.12±0.25	0.128	0.393	3.049	0.18
Flavor	8.12±0.25	8.00±0.40	8.37±0.25	7.25±0.28	7.25±0.28	6.50±0.40	0.215	0.469	3.475	0.152
Mouthfeel	8.00±0.40	8.12±0.25	8.25±0.28	7.50±0.40	7.25±0.28	6.25±0.28	0.203	0.442	3.283	0.203
Overall acceptability	8.12±0.25	8.00±0.40	8.37±0.25	8.10±0.25	7.37±0.25	6.37±0.25	0.146	0.451	3.285	0.257

n=3; Significant difference (p<0.05).

physico-chemical traits of basundi. Moisture content decreases from 54.7 to 52.62% with decreasing quantity of ashwagandha powder.

Total solid content

The total solid content was found to be highest in FCMP (52.47±0.22) and lowest in the control sample (48.58±0.20%) ($p<0.05$). The total solid increased with the increase in the addition of ashwagandha powder (Table 3). Veer *et al.* (2019a) observed an increased total solid content from 34.60 to 35.80 % with an ashwagandha powder from 0 to 4 %, resp. in shrikhand.

Fat

Paneer samples supplemented with ashwagandha differed significantly in terms of fat content due to the use of milk variants with different fat content. The control had the highest fat content of 24.49±0.20% followed by FCMP, CMP and TMP ($p<0.05$) (Table 3). According to Kumari and Gupta (2016), ashwagandha root powder has a fat content of 0.3 g per 100 g, hence the addition of 0.4% ashwagandha powder does not affect the paneer's fat content. Baliram (2018) observed a negligible variation in fat content (8.25 to 8.23%) upon increasing ashwagandha powder content from 0 to 1%.

Protein

FCMP had a protein content of 20.57±0.05% followed by control, TMP and CMP ($p<0.05$) (Table 3). Karadbhaje and Bhoyarkar (2010) reported that the protein content of ashwagandha powder was 3.45%. It can be inferred from the analysis that the addition of ashwagandha had no significant effect on the protein content of paneer. Baliram (2018) also observed a negligible increase in the protein content of shrikhand. 9.11% of protein content in shrikhand was increased to 9.13% on addition of 1% ashwagandha powder.

Ash content

The highest value of ash content value was observed in FCMP 2.24±0.03% followed by control, CMP and TMP ($p<0.05$) (Table 3), which contains several constituents including alkaloids and phenolic compounds and is also high in iron content. Oraon (2014) observed a rise in mineral composition (1.85 to 2.14%) with a respective increasing ashwagandha content (0 to 0.3%)

Titrateable acidity (TA) (% Lactic acid)

The highest TA was observed in the control sample (0.17±0.01%). The FCMP, TMP and CMP had 0.15±0.02%, 0.13±0.02% and 0.16±0.01%, resp. ($p<0.05$). As per BIS regulations, TA (max.) of paneer is 0.50% but no any analyzed samples had TA up to it. This could be due to the lower initial acidity of milk and the concentration of coagulant used (Table 3). Jayasinghe *et al.* (2023) also observed 0.15% acidity in paneer sample coagulated with citric acid.

Free fatty acid (FFA) (% Oleic acid)

FFA analysis provides a measure of the hydrolytic rancidity of paneer. FFA content in the control sample (0.55±0.02%), followed by TMP, FCMP and CMP ($p<0.05$) (Table 3). Withan addition of ashwagandha the FFA content was constant and so increased stability against lipolytic changes during storage. Similar findings were noted by Oraon (2014) in ashwagandha fortified basundi.

Antioxidant activity

An antioxidative activity of paneer samples was determined by DPPH inhibiting capacity and TPC (Table 4). Kumari and Gupta (2016) studied about the polyphenols content (19.0 mg) and % DPPH inhibition (67.16%) of dehydrated ashwagandha root powder. This present study showed a significant increase in antioxidative properties of paneer than the control sample. FCMP (46.08±0.03%) showed

Table 3: Physico-chemical analysis of paneer samples.

Parameters	Control	FCM	TMP	CMP	SEM	CD 1%	CV	SED
Moisture (%)	51.42±1.37	47.53±2.35	49.58±2.49	48.40±1.89	0.59	1.95	4.92	0.83
Total solids (%)	48.58±1.37	52.47±2.35	50.41±2.49	51.59±1.89	0.571	1.891	1.948	0.808
Fat (%)	24.49±0.98	22.40±1.07	17.44±0.87	18.32±1.13	0.587	1.943	4.923	0.831
FFA (%)	0.55±0.31	0.36±0.11	0.43±0.16	0.36±0.18	0.011	0.038	4.657	0.016
Protein (%)	20.55±1.37	20.57±1.33	18.45±0.99	16.70±1.08	0.481	1.592	4.366	0.68
Ash (%)	2.06±0.39	2.24±0.47	1.63±0.29	1.95±0.31	0.031	0.103	2.736	0.044
Titrateable acidity (%)	0.17±0.01	0.15±0.04	0.13±0.03	0.16±0.04	0.002	0.006	1.883	0.093

FCMP: Full cream milk paneer; TMP: Tonned milk paneer; CMP: Cow milk paneer; n=3, Significant difference ($p<0.05$).

Table 4: Antioxidant activity and TPC of paneer samples.

Parameters	Control	FCMP	TMP	CMP	SEM	C D 1%	CV	SED
DPPH inhibiting capacity (%)	26.47±0.11	46.08±0.03	34.49±0.09	42.75±0.06	0.614	2.035	2.842	0.869
TPC (µg GAE/g)	18.55±0.26	22.42±0.44	18.28±0.13	19.55±0.39	0.359	1.188	3.154	0.507

FCMP: Full cream milk paneer; TMP: Tonned milk paneer; CMP: Cow milk paneer; n=3, Significant difference ($p<0.05$).

Table 5: Texture profile analysis of paneer samples.

Parameters	Period (day)	Control	FCMP	TMP	CMP	SEM	CD (1%)	CV	SED
Hardness (g)	0 th	128.57±3.25	125.41±2.65	145.29±2.84	120.42±3.03	2.05	6.80	2.74	2.90
	7 th	134.37±1.25	132.42 ± 0.23	148.63 ± 0.08	124.62 ± 0.20	2.002	6.529	2.568	2.831
Cohesiveness	0 th	0.54±0.12	0.43±0.09	0.37±0.08	0.64±0.11	0.01	0.03	3.51	0.014
	7 th	0.43±0.07	0.57± 0.02	0.45 ± 0.01	0.75 ± 0.01	0.009	0.028	2.696	0.012
Springiness (mm)	0 th	1.24±0.32	1.04±0.28	0.66±0.18	0.72±0.16	0.02	0.08	4.31	0.03
	7 th	0.87±0.03	0.96±0.02	0.45 ± 0.02	0.55 ± 0.01	0.017	0.055	4.097	0.024
Gumminess (N)	0 th	0.68±0.03	0.53±0.09	0.53±0.04	0.75±0.04	0.01	0.04	3.25	0.016
	7 th	0.67±0.07	0.73 ± 0.02	0.66 ± 0.02	0.91 ± 0.01	0.011	0.036	2.57	0.016
Chewiness (g)	0 th	83.80±2.76	56.90±3.21	36.11±2.17	56.04±3.85	0.94	3.12	2.81	1.334
	7 th	80.56±1.03	72.94 ± 2.63	30.72 ± 0.67	54.47 ± 1.31	1.632	5.321	4.746	2.308
Adhesiveness (Nm)	0 th	-2.26±0.04	-2.56±-0.12	-3.24±-0.15	-3.36±-0.21	0.10	0.22	-4.11	0.096
	7 th	-2.03±0.11	-1.95±-0.03	-2.55±-0.37	-2.83±-0.02	0.036	0.116	-2.64	0.050

FCMP: Full cream milk paneer; TMP: Tonned milk paneer; CMP: Cow milk paneer; n=3, Significant difference (p<0.05).

Table 6: Microbial analysis of paneer samples.

Parameters	Period (day)	Control	FCMP	TMP	CMP
Total plate count (cfu/g × 10 ³)	0 th	3.63±0.37	2.43±0.20	2.53±0.37	2.6±0.10
	7 th	6.39±0.53	3.53±0.23	10.33±0.15	20.5±0.10
Yeast and mold (cfu/g × 10 ¹)	0 th	ND	ND	1.30±0.26	2.46±0.25
	7 th	2.6±0.34	2.23±0.25	2.60±0.26	3.43±0.30
Coliform count (cfu/g × 10 ¹)	0 th	ND	ND	ND	ND
	7 th	ND	ND	ND	ND

FCMP: Full cream milk paneer; TMP: Tonned milk paneer; CMP: Cow milk paneer; n=3, Significant difference (p<0.05).

the highest activity followed by CMP (42.75±0.06%), TMP (34.49±0.09%) and control (26.47±0.11%). Kumar *et al.* (2024) compared a TPC and % DPPH inhibition of control (negligible and 75.67±0.02%, resp.) and ashwagandha added ghee (62.85±0.02 and 83.9±0.02, resp.). As per Vijayakumar (2011), the antioxidant activity of ashwagandha ethanolic extract (67.70%) is higher than its aqueous equivalent (49.93%).

Total phenolic content (µg GAE/g)

Ashwagandha contains phyto-steroid withanolides and withaferins, which help to increase the phenolic content on fortification. The FCMP 22.42±0.44 µgGAE/g had the highest phenol concentration. Whereas control had 18.55±0.26µgGAE/g, TMP had 18.28±0.13 µgGAE/g and CMP had 19.55±0.39 µgGAE/g. Vijayakumar, (2011) evaluated that the ethanolic extract of ashwagandha had a phenolic value of 23.95 µg GAE/gm while aqueous extract had 20.88 µgGAE/gm.

Texture analysis

Primary textural properties are hardness, cohesiveness and springiness while secondary properties are gumminess, chewiness and adhesiveness. The evaluated data over a period of 7 days for these properties has been depicted in (Table 5) and all are significantly differed (p<0.05).

The hardness (g) value of all the prepared and control sample was found to be increased. On 0th and 7th days of study, TMP (145.29±2.84 and 148.63±0.08, resp.) showed

the highest value for it followed by control (128.57±3.25 and 134.37±1.25, resp.), FCMP (125.41±2.65 and 132.42±0.23, resp.) and CMP (120.42±3.03 and 124.62±0.20, resp.) There was a significant increase from 8.331 to 14.223 kg. in the hardness of paneer samples in storage (7 days) under refrigerated conditions which showed agreement with findings of Dongare *et al.* (2019).

The highest and lowest values for cohesiveness were found in control (0.54±0.02) and TMP (0.37±0.01), resp. Obtained results showed decreased cohesiveness in control sample (0.54±0.12 to 0.43±0.07) while increased in treated samples [FCM (0.43±0.09 to 0.57±0.02), TMP (0.37±0.08 to 0.45±0.01) and CMP (0.64±0.11 to 0.75±0.01) over a period of 7 days. The variation in cohesiveness value can be due to different milk compositions used for paneer manufacturing. Uprit and Mishra (2004) stated that the nature of the protein matrix and the extent of fat dispersion in paneer contribute to cohesiveness.

The springiness (mm) of the control sample was found to decrease at highest extent from 1.24±0.32 to 0.87±0.03 during study. All other treated samples also showed decreasing trend for springiness at low extent. Husain (2016) in ashwagandha-fortified Sandesh found decreasing trend from 0.664 (control) to 0.570 (treated).

The gumminess (N) of the control (0.68±0.03) sample was observed to decrease (0.67±0.07), whereas, all treated samples viz. CMP, TMP and FCMP found to increase from 0.75±0.04 to 0.91±0.01, 0.53±0.04 to 0.66±0.02 and FCMP

0.53±0.09 to 0.73±0.02, resp. during storage period. Similar results were reported by Sharath and Divya (2020) in paneer samples prepared using citric acid as a coagulant.

Over a storage period, chewiness (g) of Control was found to be decreased from 83.80±2.76 to 80.56±1.03, TMP 36.11±2.17 to 30.72±0.67, CMP 56.04±3.85 to 54.47±1.31, whereas increased from 56.90±3.21 to 72.94±2.63 in FCMP sample. Chewiness depends on characteristics like the composition of milk, moisture and fat contents. According to Sindhu *et al.* (2000), paneer tends to be chewier when it has more protein and calcium content. Husain (2016) found that the addition of ashwagandha in Sandesh reduced the chewiness from 68.8 kg to 60.91 kg. An adhesiveness (Nm) of the all the analysed sample was found to be decreased like, in control from -2.26±0.04 to -2.03±0.11, in CMP -3.36±0.21 to -2.83±0.02, in TMP -3.24±0.15 to -2.83±0.02 and in FCMP -2.56±0.12 to -1.95±0.03. Prakashrao (2013) reported that the adhesiveness of paneer decreases from -3.983±0.616 to -0.606±0.061 upon storage of 21 days under refrigeration conditions for a long period.

Microbial analysis

Microbial analysis was carried out within the permitted range during 7 days storage (Table 6). BIS standards for microbial content of paneer are <5×10⁵/g total plate count, <250 g yeast and mold and <50/g coliform count. From the analyzed data, it can be inferred that all the samples had TPC under BIS standards over a period of 0th to 7th days from 3.63±0.37 to 6.39±0.53 (cfu/g × 10³) in control, 2.43±0.20 to 3.53±0.23 (cfu/g × 10³) in FCMP, 2.53±0.37 to 10.33±0.15 (cfu/g × 10³) in TMP and 2.6±0.10 to 20.5±0.10 (cfu/g × 10³) in CMP, resp. The results observed for the Standard plate count of samples were below the range of FSSAI standards *i.e.* 1.5 × 10⁵ to 3.5 × 10⁵ cfu/g. A similar trend was reported in ashwagandha fortified ice cream (Veer *et al.* 2019 b). The yeast and mold count was not detected in the control sample and FCMP. While TMP and CMP had 1.30±0.26 cfu/g × 10¹ and 2.46±0.25 cfu/g × 10¹, resp on day 0. Whereas on 7th day, control, FCMP, TMP and CMP showed 2.6±0.34 cfu/g × 10¹, 2.23±0.25 cfu/g × 10¹, 2.60±0.26 cfu/g × 10¹ and 3.43±0.30, resp. Husain (2016) reported similar findings in ashwagandha-fortified Sandesh. Oraon (2014) observed similar findings in ashwagandha-fortified Basundi. There was no coliform count in the samples over a storage. The results were in agreement with the findings of Janardan (2019). Babayi *et al.* (2004) reported that the methanolic extract of ashwagandha has inhibitory action against *Staphylococcus aureus* and *E. coli*. The main variables affecting the paneer's microbiological quality are its moisture content, milk quality, manufacturing process and storage conditions.

CONCLUSION

The demand for healthy and nutritious food has escalated after the COVID-19 pandemic and so needs development. The findings of the current research investigation are summarized. Based on sensory analysis, the stage 1

addition of ashwagandha powder (before heating of milk) had the most acceptance by panelists and later with 0.4% ashwagandha powder. The optimized ashwagandha paneer was made in three milk variants *viz.* Toned, cow milk and full cream milk. Their physicochemical, textural and microbial parameters were evaluated by taking market paneer as a control. The effect of different variants of milk was observed from the obtained data. After analysing all the samples, 0.4% FCMP was found to have better stability in composition and other aspects too over a 7 days period of storage. Its moisture content was 47.53%, lower than control. FCMP had the highest TS (52.47%) and Ash (2.24%). Titratable acidity was lower than BIS and FSSAI prescribed standards. The lowest FFA content in FCMP emphasizes its storage stability. No significant change in protein content was observed in paneer samples upon ashwagandha addition. The antioxidant property was increased and the % DPPH scavenging activity was highest for FCMP (46.08%) compared to the control sample (26.47%). The TPC of FCMP (22.42±0.44 µgGAE/g) was higher than other samples. Control and FCMP samples had close values for their textural (except chewiness) and microbial analysis. It was evident from the analysis that a good quality paneer with higher therapeutic value can be developed by incorporating 0.4% ashwagandha in full cream milk and it can be utilized by all sections of people as a culinary dish.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

No animals were used for the experiment.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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