Indian J Anim Health (2024), 63(1): 60-65
DOI: https://doi.org/10.36062/ijah.2024.16023

Research Article

Application of developed film from sago starch and garlic extract to control storage related sensory changes in paneer

D. P. S. Gogineni[1], P. K. Singh[2*], S. Meshram[1], S. Yadav[2], N. Shrivastav[3], R. Singh[4], N. Agrawal[2] and S. Tomar[1]

[1]Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, Rewa- 486 001, Madhya Pradesh, India; [2]Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, Jabalpur- 482 001, Madhya Pradesh, India; [3]Department of Veterinary Microbiology, College of Veterinary Science and Animal Husbandry, Rewa- 486 001, Madhya Pradesh, India; [4]Department of Veterinary Public Health and Epidemiology, College of Veterinary Science and Animal Husbandry, Jabalpur- 482 001, Madhya Pradesh, India

Abstract

Packaging film variants (T1, T2 and T3) and control (C), where T1: sago starch-based developed film, T2: sago starch-based developed film with edible gum coating, T3: sago starch-based developed film with garlic extract integration and edible gum coating and C: low-density polyethylene film, were developed. Paneer was packaged in the developed films to assess the sensory attributes under refrigeration storage (4±1°C). In the current investigation, T2 and T3 had a considerably (P≤0.05) higher score of general colour and appearance on storage day 12 than C and T1. On storage days 9 and 12, T3 had a significantly (P≤0.05) greater flavour value than control and T1. On days 6, 9 and 12, T3 had a considerably (P≤ 0.05) higher juiciness score than T1. The texture of T3 was considerably (P≤0.05) higher than the control and T1 on the 9th and 12th day of storage. On day 9, significantly (P≤0.05) greater overall acceptability scores were observed in T3 in comparison to control; however, on day 12, there was a substantial difference which was significant (P≤0.05) among all the treatments, indicating the superiority of T2 and T3 samples. Regardless of packaging, a decrease in the scores for general colour and appearance, flavour, juiciness, texture, and overall acceptability was observed as the storage period progressed, but the reduction in T3 was considerably less in comparison to other variants especially on the 9th and 12th day of storage. Thus, it was observed that a starch-based packaging film with edible gum and garlic extract shows promising results.

Keywords: Garlic extract, Packaging film, Packaging, Paneer, Sensory

Highlights

- Synthetic materials for food packaging are discouraged.
- The concept of biodegradability is environmentally friendly.
- Sago (starch) could be a promising material for packaging film.

INTRODUCTION

With a production of approximately 230.58 million tonnes in 2022-23, India is the world's largest producer of milk (BAHS, 2023). Paneer is an important acid-coagulated indigenous milk product that is widely used in cooking alongside vegetables. Paneer, according to FSSAI Rules (2011), is a product made from cow or buffalo milk or a combination of the two through precipitation with sour milk, lactic acid, or citric acid. Because of its high moisture content (approximately 55%), paneer has a shelf life of not more than one day at room temperature and up to a week at refrigeration temperature (Kumar *et al.*, 2014). Keeping quality of the product is compromised by the insufficiency of packaging materials, and poor sensory features have been reported under refrigeration storage, which may lead to the rejection of the product on sensory parameters. However, advanced packaging material with active ingredients for enhanced functionality can have good potential to protect the sensory quality of the product.

Packaging is an essential component of the food industry. Synthetic packaging materials are used in almost all areas of production, including food packaging. The world is producing twice as much plastic waste as two decades ago, with the bulk of it

*Corresponding Author, E-mail: drpradeeplpt@yahoo.co.in

ending up in landfills, incinerated or leaking into the environment, and only 9% successfully recycled (OECD, 2022). The concept of biodegradable packaging offers benefits from both user-friendly and eco-friendly points of view, for which the raw materials are primarily derived from agricultural sources, and it capitalizes on natural resource conservation with a focus on environmental friendliness and safety (Ambrose, 2019). Numerous studies show that natural polysaccharides are well suited for use as packaging material for fresh food and can often be an important alternative to synthetic compounds (Kocira *et al.*, 2021). Biodegradable packaging materials include polyhydroxyalkanoates (PHAs), polylactic acid (PLA), starch blends, cellulose-based plastics, lignin-based polymer composites, chitin, and many other composite materials. Starch is an enticing biopolymer that can replace conventional plastics in food packaging because of its biodegradability, relative abundance, chemical inertness, and resistance to degradation, as well as its excellent film-forming capabilities. Sago is a starch derived from the spongy center, or pith, of tropical palm stems, particularly those of *Metroxylon sagu*. Commercially, sago is frequently produced in the form of "pearls".

Packaging with some natural active ingredients may enhance the product quality. Organosulfur compounds of garlic exhibit a range of antimicrobial properties such as bactericidal, anti-biofilm, anti-toxin, and anti-quorum sensing activity against a wide range of bacteria including multi-drug resistant (MDR) strains (Bhatwalkar *et al.*, 2021). Garlic is known to contain natural antioxidants that can remove reactive oxygen species (ROS) and reduce lipid peroxides and low-density lipoprotein (LDL) oxidation (Saravanan and Prakash, 2004). The main antioxidant compounds in garlic volatiles were found to be allicin, diallyl disulfide and diallyl trisulphide (Kim *et al.*, 1997). These antimicrobial and antioxidant properties of garlic can lead to improvement of sensory scores as they check the deteriorative changes in the product. The packaging intervention here aims to explore an alternative of plastic to package the paneer and assess, keeping sensory qualities as close to the fresh product as possible. In the present study, a starch-based packaging film was developed with garlic extract, and the sensory attributes of the paneer were evaluated during refrigerated (4±1°C) storage.

MATERIALS AND METHODS

The investigation was conducted in the Department of Livestock Product Technology, College of Veterinary Science and Animal Husbandry, Rewa. Buffalo milk with a fat percentage of about 6% and SNF (solids not fat) of 9% was procured from the college dairy unit for the preparation of paneer. Citric acid, acetic acid, glycerol, edible gum and sago pearls of food grade used for the preparation of paneer and packaging film were procured from the local market. Sago pearls were ground into fine powder and used for the preparation of the desired film. LDPE films for packaging of paneer and garlic bulbs used in the experiment were procured from the local market during the storage study. Garlic cloves were peeled, cleaned and kept for further use. All the media, chemicals, and reagents of analytical grade, glass and plastic wares required for various analyses were procured from standard firms viz., Himedia Chemicals Pvt Ltd, S.D Fine Chemicals Pvt Ltd, Central Drug House (CDH) Pvt. Ltd., Borosil Glassware, etc.

In this experiment, the study was conducted between 4 packaging films: Group C- Low-density polyethylene (LDPE), Group T1- Developed film from sago starch, Group T2- Developed film from sago starch + coating of edible gums, Group T3- Developed film from sago starch with the incorporation of garlic extract + coating of edible gums.

Preparation of packaging film T1: Preparation of packaging film from sago starch was done by taking 10% (w/w) of finely ground sago pearl powder in a beaker with 80% (w/v) of distilled water and left aside for a few hours. This mixture was finely ground to make a uniform solution and heated at 150°C until the mixture gets a thick texture. To this mixture, glycerol was added @5% as a plasticizer and 10% acetic acid @5%, both w/v. The solution was then poured on spreading sheets and placed for drying in a hot air oven for 20-24 hrs. at 45°C; after proper drying, the film was peeled from spreading sheets and stored for packaging of paneer.

Preparation of packaging film T2: Edible gum from the babool plant (*Vachellia nilotica*) dissolved in equal proportion of distilled was spread over the second batch of dried and peeled sago sheet obtained as in T1 variant on a single side and placed in a hot air oven for 1-2 hrs. at 45°C, thereafter they were stored for packaging of paneer

Preparation of packaging film T3: About 100 g of garlic bulbs were peeled, cleaned, and washed with sterile distilled water and were surface sterilized using 75% (v/v) ethanol for 60 seconds and homogenized

aseptically. The homogenized mixture was filtered using a sterile muslin cloth, and the extract obtained was considered a 100% concentration of the extract, which was stored at refrigeration temperature till further use (Indu *et al.*, 2006).

Preparation of packaging film from sago starch was done by taking 10% (w/w) of finely ground sago pearl powder in a beaker with 70% (w/v) of distilled water, 10% of garlic extract added and left aside for a few hours; thereafter the mixture was finely ground with the help of high-power mixer grinder to make a uniform solution of the mixture. The rest of the preparation of the film is similar to the T2 variant in the second experiment.

Preparation of paneer: Paneer was prepared using the method suggested by Lamdande *et al*. (2012). It was then packaged in LDPE as Control and T1, T2 and T3 films as experiment groups and placed for storage study in refrigeration at 4±1°C.

Storage study of paneer: The product was stored at refrigeration (4±1°C) temperature, and samples were analyzed from 0 day at a regular interval of 3 days for a period of 12 days or spoilage/whichever is earlier. The sensory parameters were analyzed to assess the product quality during storage.

Sensory evaluation: The paneer packaged in different packaging materials was organoleptically evaluated by a semi-trained panel of 6 judges on day 0, and it was repeated again on the 3rd, 6th, 9th and 12th days. The samples were judged for various sensory attributes using nine-point descriptive scales (Keeton, 1983). The scores of 6 judges were averaged and recorded as the mean value for the sensory score. Each panellist evaluated four samples (identified by codes) in a balanced sequential order.

Statistical analysis: Data was analyzed statistically on 'SPSS-22.0' (SPSS Inc., Chicago, II USA) software package as per standard methods (Snedecor and Cochran, 2007). The average values were reported along with standard deviation. The statistical significance was estimated at 5% level (P≤0.05).

RESULTS

Colour and appearance: The colour and appearance scores obtained for paneer packaged and stored under refrigeration in control, T1, T2 and T3 samples on 0 day were 7.46, 7.42, 7.38, and 7.5 respectively, which gradually decreased in all the groups throughout the study period (Table 1). The study reveals that there was a significant (P≤0.05) change in colour and appearance score obtained on each subsequent day of storage, and on the last day (12th), the values observed in control, T1, T2 and T3 were 4.21, 4.08, 4.46 and 4.71, respectively. The colour and appearance score obtained was gradually reduced in all the treatments under study. However, the observation was significantly (P≤0.05) different in trials from the 6th day onwards. The study showed that maximum change in colour and appearance score was observed in the T1 group with a change from day 0 score obtained from 7.42 to 4.08 on day 12, whereas comparatively lesser variation in scores obtained was observed in the T3 group with 7.5 on day 0 to 4.71 on day 12.

Flavour: The flavour values of paneer packaged and stored under refrigeration revealed that in Control, T1, T2 and T3 on 0 day, the observations were 7.33, 7.38, 7.29 and 7.33, respectively, which gradually showed a decrease throughout the study (Table 1). The study shows that there was a significant (P≤0.05) change in flavour on each subsequent day of storage; on the last day (12th), the values noticed in Control, T1, T2 and T3 were 4.17, 4.40, 4.54 and 4.79, respectively. With time, the flavour was gradually reduced in all the samples under study. However, the observation was significantly (P≤0.05) different in trials from the 9th day onwards. The study shows that the highest flavour loss was observed in the T1 group with a change from day 0 flavour from 7.38 to 4.40 on day 12, whereas a comparatively lesser change in flavour was observed in the T3 group with 7.33 on day 0 to 4.79 on day 12.

Juiciness values: The juiciness grades of paneer packaged during storage in Control, T1, T2 and T3 on 0 days were found to be 7.21, 7.21, 7.33 and 7.38, respectively, which gradually decreased with the progress of the study period (Table 1). The study shows that there was a significant (P≤0.05) change in juiciness scores on each subsequent day of storage, and the samples evaluated on the last day (12th) showed that in Control, T1, T2 and T3, the values were 4.29, 4.04, 4.54 and 4.79, respectively. The juiciness scores revealed that the observation was significantly (P≤0.05) different in trials from the 6th day onwards. The study shows that maximum juiciness value was observed in the T1 group with a change from day 0 juiciness grades from 7.21 to 4.04 on day 12, whereas a comparatively lesser change in juiciness grade was observed in the T3 group with 7.38 on day 0 to 4.79 on day 12.

Table 1. Effect of developed film from sago starch and garlic extract on sensory properties of the packaged paneer during refrigeration storage

Treatment	Storage days				
	0	3	6	9	12
			Colour and appearance		
C	$7.46^{A}\pm0.10$	$7.00^{B}\pm0.22$	$6.42^{bC}\pm0.13$	$5.75^{cD}\pm0.16$	$4.21^{cE}\pm0.10$
T1	$7.42^{A}\pm0.13$	$6.96^{B}\pm0.19$	$6.33^{bC}\pm0.13$	$5.83^{cD}\pm0.13$	$4.08^{cE}\pm0.13$
T2	$7.38^{A}\pm0.14$	$6.92^{B}\pm0.13$	$6.46^{bC}\pm0.10$	$6.08^{bD}\pm0.13$	$4.46^{bE}\pm0.10$
T3	$7.50^{A}\pm0.16$	$7.08^{B}\pm0.13$	$6.67^{aC}\pm0.13$	$6.42^{aD}\pm0.13$	$4.71^{aE}\pm0.10$
			Flavour		
C	$7.33^{A}\pm0.13$	$6.96^{B}\pm0.10$	$6.63^{C}\pm0.14$	$6.08^{cD}\pm0.13$	$4.17^{cE}\pm0.13$
T1	$7.38^{A}\pm0.14$	$6.92^{B}\pm0.13$	$6.58^{C}\pm0.13$	$6.17^{bcD}\pm0.20$	$4.40^{dE}\pm0.10$
T2	$7.29^{A}\pm0.19$	$6.88^{B}\pm0.14$	$6.67^{C}\pm0.13$	$6.29^{abD}\pm0.10$	$4.54^{bE}\pm0.10$
T3	$7.33^{A}\pm0.13$	$6.96^{B}\pm0.10$	$6.71^{C}\pm0.10$	$6.42^{aD}\pm0.13$	$4.79^{aE}\pm0.10$
			Juiciness		
C	$7.21^{A}\pm0.19$	$6.96^{B}\pm0.10$	$6.63^{abC}\pm0.14$	$6.08^{bD}\pm0.13$	$4.29^{cE}\pm0.10$
T1	$7.21^{A}\pm0.13$	$6.88^{B}\pm0.14$	$6.50^{bC}\pm0.16$	$6.04^{bD}\pm0.10$	$4.04^{dE}\pm0.10$
T2	$7.33^{A}\pm0.13$	$6.92^{B}\pm0.13$	$6.67^{abC}\pm0.13$	$6.13^{abD}\pm0.14$	$4.54^{bE}\pm0.10$
T3	$7.38^{A}\pm0.14$	$6.96^{B}\pm0.10$	$6.71^{aC}\pm0.10$	$6.25^{aD}\pm0.16$	$4.79^{aE}\pm0.10$
			Texture		
C	$7.32^{A}\pm0.13$	$7.00^{B}\pm0.16$	$6.67^{C}\pm0.13$	$6.13^{bD}\pm0.14$	$4.33^{cE}\pm0.20$
T1	$7.29^{A}\pm0.10$	$6.92^{B}\pm0.10$	$6.54^{C}\pm0.10$	$6.08^{bD}\pm0.13$	$4.08^{dE}\pm0.13$
T2	$7.38^{A}\pm0.14$	$6.96^{B}\pm0.10$	$6.71^{C}\pm0.10$	$6.17^{abD}\pm0.13$	$4.58^{bE}\pm0.13$
T3	$7.38^{A}\pm0.14$	$7.04^{B}\pm0.10$	$6.75^{C}\pm0.16$	$6.33^{aD}\pm0.13$	$4.88^{aE}\pm0.21$
			Overall acceptability		
C	$7.21^{A}\pm0.10$	$6.83^{B}\pm0.13$	$6.38^{C}\pm0.14$	$5.88^{bD}\pm0.14$	$4.21^{dE}\pm0.10$
T1	$7.17^{A}\pm0.13$	$6.88^{B}\pm0.14$	$6.33^{C}\pm0.13$	$5.79^{abD}\pm0.19$	$4.04^{cE}\pm0.10$
T2	$7.29^{A}\pm0.10$	$6.92^{B}\pm0.13$	$6.38^{C}\pm0.14$	$5.88^{abD}\pm0.14$	$4.54^{bE}\pm0.10$
T3	$7.25^{A}\pm0.16$	$7.00^{B}\pm0.16$	$6.42^{C}\pm0.13$	$6.00^{aD}\pm0.16$	$4.71^{aE}\pm0.10$

Means (Mean±SD, n=6) with different superscripts in lower case in a column and upper case in a row differ significantly ($P\leq0.05$) for a single parameter. C = Control, T1 = Film from sago starch, T2 = Film from sago starch + coating of edible gum, T3 = Film from sago starch with garlic extract incorporated + coating of edible gum

Texture values: The texture scores of paneer packaged and stored (refrigeration) in Control, T1, T2 and T3 on 0 day were 7.32, 7.29, 7.38 and 7.38, respectively, and they gradually decreased with the storage of the product (Table 1). During the last day of the storage, a significantly higher texture value was found in T3, whereas a significantly ($P\leq0.05$) lower texture value was identified in T1 in comparison to the control. During the storage of the product, T3 showed no significant difference on days 0, 3 and 6. However, there was a significant ($P\leq0.05$) difference between the control and T1 in texture scores on days 9 and 12; the score decreased from 7.38 on day 0 to 4.88 on day 12 in the T3 samples. In the T1 group, there was no significant ($P\leq0.05$) difference observed on day 0 and day 3. However, the score decreased from 7.29 on day 0 to 4.08 on day 12.

Overall acceptability: The overall acceptance scores of paneer packaged in Control, T1, T2 and T3 on 0 days were reported as 7.21, 7.17, 7.29 and 7.25, respectively (Table 1). The values constantly decreased in all groups throughout the study. The investigation revealed that there was a significant ($P\leq0.05$) change in overall acceptance grades on each subsequent day of storage. The samples were evaluated on the last day (12^{th}), and the values observed for Control, T1, T2 and T3 were 4.21, 4.04, 4.54 and 4.71, respectively. With time, the overall acceptance values gradually reduced in all the samples under study. However, the observation was significantly ($P\leq0.05$) different in trials on the 9^{th} and 12^{th} day. The study shows that utmost overall acceptance was observed in the T3 group in comparison to the control when the scores of the 9^{th} and 12^{th} day were evaluated.

DISCUSSION

The investigation revealed that the product in all the treatments was of poor sensory grade on the scale of colour and appearance when the 12th day of storage was studied, and appreciable scores were noticed till the 9th day. The present study is in agreement with the findings of Foda *et al.* (2008), Hamid (2014) and Singh *et al.* (2014). The study showed that maximum change in colour and appearance score was observed in the T1 group, whereas comparatively lesser variation in scores obtained was observed in the T3 group. Similar results were observed by Kumar (1989), Bector *et al*. (1999) and Khatkar *et al*. (2017). Significantly (P≤0.05) higher scores were recorded in T3 samples in comparison to T1 and T2, and the probable reason could be the appreciable effect of packaging material coated with gum and incorporated with garlic extract. Salim *et al.* (2022) also reported that packaging films incorporating garlic extract have commendable antibacterial activity for active food packaging applications.

The study revealed that there was a significant (P≤0.05) change in flavour on each subsequent day of storage, and the findings in correlation with Sanyal *et al.* (2006), Foda *et al.* (2008), Singh *et al.* (2014) and Hamid (2014). The sensory scores for the flavour indicate that the product in all the treatments was of poor grade on the 12th day of storage, and appreciable flavour values were there till the 9th day time only. The study shows that the highest flavour loss was observed in the T1 group, whereas a comparatively lesser change in flavour was observed in the T3 group. Similar results were observed by Kumar (1989) and Bector *et al.* (1999). Significantly (P≤0.05) superior scores were recorded on the 9th and 12th day of storage in T3 samples in comparison to T1 samples, indicating the role of gum coating and garlic extract, which improved the barrier property and checked the flavour deterioration, respectively. Dirpan *et al*. (2022) also observed that there is a lower fall in physicochemical, colour, and flavor score of meat packaged in films developed with garlic extract which is due to the bioactive compound allicin that inhibits microbial growth and hence the lesser release of ammonia and other off-flavor compounds.

The study revealed that there was a significant (P≤0.05) change in juiciness scores with subsequent days of storage. The scores also revealed that the product in all the treatments was of poor juiciness scores on the 12th day of storage, and acceptable juiciness was observed till the 9th day. The study is in agreement with Sanyal *et al.* (2006), Foda *et al.* (2008), Singh *et al.* (2014) and Hamid (2014). The study showed that maximum juiciness value was observed in the T1 group whereas a comparatively lesser change in juiciness grade was observed in the T3 samples and had significantly (P≤0.05) superior scores in comparison to T1 samples from the 6th day onwards, indicating the effect of gum coating on the film and garlic extract. The same results were observed by Kumar (1989) and Bector *et al.* (1999).

The texture scores of the product gradually decreased with the storage. The present study co-relates with Sanyal *et al.* (2006), Foda *et al.* (2008), Hamid (2014) and Singh *et al.* (2014). The study showed a significant (P≤0.05) difference in the value which decreased with the subsequent storage of the product in all groups. The scores also revealed that the product in all the treatments had poor texture scores on the 12th day of storage, and appreciable texture was noticed till the 9th day only. With the storage, the T3 showed no significant difference on days 0, 3 and 6; however, there was a significant (P≤0.05) difference in the control and T1 in texture scores on days 9 and 12. Decreases in sensory scores such as texture and flavor were also observed by Devaki *et al*. (2021) in spice-based paneer prepared and stored for up to 25 days.

The findings revealed that there was a significant (P≤0.05) change in overall acceptance grades on each subsequent day of storage. Similar findings have been observed by Sanyal *et al.* (2006), Foda *et al.* (2008), Hamid (2014) and Singh *et al.* (2014). The scores also revealed that the product in all the treatments had poor sensory scores on the 12th day of storage. Hence, the sensory values indicate that the product was acceptable on the sensory parameters till the 9th day of study. Similar findings were found by Kumar (1989) and Bector *et al.* (1999).

During the storage trial under refrigeration (4°C), regardless of packaging, the overall four group's scores for general colour and appearance, flavour, juiciness, texture, and overall acceptability fell considerably (P≤0.05) as time progressed. In the current investigation, T2 and T3 had a considerably (P≤0.05) higher score of general colour and appearance on storage day 12 than C and T1. On storage days 9 and 12, T3 had a significantly (P≤0.05) greater flavour value than Control and T1. On days 6, 9, and 12, T3 had a considerably (P≤0.05) higher juiciness score than T1. The texture of T3 was considerably (P≤0.05) higher than the control and T1 on the 9th and 12th day of storage. On day 9, significantly (P≤0.05) greater overall acceptability scores were observed in T3 in comparison to control; however, on day 12, there was a substantial difference, which was significant (P≤0.05) among all the treatments while indicating the superiority of T2 and T3 samples. Thus, the addition of edible gum to a packaging film improved mechanical and barrier properties, whereas garlic extract improved the sensory quality of the product. A starch-based packaging film with edible gum and garlic extract shows promising results and has the potential to maintain the quality of paneer stored under refrigeration. Such packaging film can prove to be an excellent alternative to LDPE films, which are a menace to the environment.

Conflict of interest: Authors declare that they do not have any conflict of interest in the study.

Author's contributions: DPSG: Has carried out all the experiments related to this manuscript; PKS, SM: Designed and supervised the study; SY, NS, RS, NA, ST: Contributed to statistical analysis and writing of the work done.

Data Availability: The data mentioned in the article will be available with the corresponding author.

ACKNOWLEDGEMENT

The office of Dean, College of Veterinary Science and Animal Husbandry, Rewa is acknowledged here for financial assistance to conduct the study. The support provided by different departments for the present study is also duly acknowledged here.

REFERENCES

Ambrose DCP, 2019. Biodegradable packaging- An eco-friendly approach. Current Agri Res, 8(1), doi: 10.12944/CARJ.8.1.02

BAHS, 2023. Basic Animal Husbandry Statistics, Government of India, Ministry of Fisheries Animal Husbandry and Dairying, Department of Animal Husbandry and Dairying, Krishi Bhawan, New Delhi, pp 7

Bector BS, Goyal GK and Gandhi DN, 1999. Chemical and microbiological changes in paneer during storage in different packaging materials. Annual Report, NDRI, pp 1998-1999

Bhatwalkar SB, Mondal R, Krishna SBN, Adam JK, Govender P *et al.*, 2021. Antibacterial properties of organosulfur compounds of garlic (*Allium sativum*). Front Microbiol, 12: 613077, doi: 10.3389/fmicb.2021.613077

Devaki CS, Rashmi HS, Pallavi R and Shekhara RN, 2021. Development and storage studies on ready to use spice-based paneer. J Adv Dairy Res, 9: 250

Dirpan A, Djalal M and Ainani AF, 2022. A simple combination of active and intelligent packaging based on garlic extract and indicator solution in extending and monitoring the meat quality stored at cold temperature. Foods, 11: 1495, doi: 10.3390/foods11101495

Foda MI, Seleet FL and El-Ghorab AH, 2008. Sensory evaluation and related volatile components of white herby cheese. Int J Dairy Sci, 3(4): 160-169, doi: 10.3923/ijds.2008.160.169

FSSAI rules, 2011. Akalank's Food Safety and Standards Act, Rules and Regulation. Akalank Publication, pp 293

Hamid OIA, 2014. Effect of cumin oil concentrations on chemical composition and sensory characteristics of Sudanese white cheese during ripening. Int J Curr Micro Appl Sci, 3(4): 961-968, doi: 10.3923/ijds.2008.79.85

Indu MN, Hatha AAM, Abirosh C, Harsha U and Vivekanandan G, 2006. Antimicrobial activity of some of the south-Indian spices against serotypes of *Escherichia coli*, Salmonella, *Listeria monocytogenes* and *Aeromonas hydrophila*. Braz J Micro, 37(2): 153-158, doi:10.1590/S1517-83822006000200011

Keeton JT, 1983. Effects of fat and NaCl/phosphate levels on the chemical and sensory properties of pork patties. J Food Sci, 48(3): 878-881, doi: 10.1111/j.1365-2621.1983.tb14921.x

Khatkar AB, Ray A and Kaur A, 2017. Studies on shelf life extension of paneer with the addition of plant essential oil and different packaging materials. Int J Curr Microbiol App Sci, 6(9): 376-389, doi: 10.20546/ijcmas.2017.609.047

Kim SM, Kubota K and Kobayashi A, 1997. Antioxidative activity of sulfur-containing flavor compounds in garlic. Biosci Biotech Biochem, 61: 1482-1485, doi: 10.1271/bbb.61.1482

Kocira A, Kozłwicz K, Panasiewicz K, Staniak M, Szpunar-Krok E *et al.*, 2021. Polysaccharides as edible films and coatings: characteristics and influence on fruit and vegetable quality- A review. Agronomy, 11(5): 813, doi: 10.3390/agronomy11050813

Kumar P, 1989. Enhancement of shelf life of paneer with food additives. MSc Thesis, Kurukshetra University

Kumar S, Rai DC, Niranjan K and Bhat ZF, 2014. Paneer- an Indian soft cheese variant: A review. J Food Sci Technol, 51(5): 821-831, doi: 10.1007/s13197-011-0567-x

Lamdande AG, Garud SR and Anil K, 2012. Impact of edible coating and different packaging treatments on microbial quality of paneer. J Food Proc Tech, 3: 159, doi: 10.4172/2157-7110.1000159

OECD, 2022. Global plastics outlook. Economic driver, environmental impacts and policy options, policy highlights. Available in: https://read.oecd-ilibrary.org/view/?ref=1128_1128022-j5crhacc6w&title=Global-plastics-outlook [Accessed on 20.11.2023]

Salim MH, Zineb K, Youness A, Ariel GC, Abdoulaye S *et al.*, 2022. Exploration of multifunctional properties of garlic skin derived cellulose nanocrystals and extracts incorporated chitosan biocomposite films for active packaging application. Int J Bio Macro, 210: 639-653, doi: 10.1016/j.ijbiomac.2022.04.220

Sanyal MK, Yadav PL, Gangopadhyay SK and Paul SC, 2006. Effect of coagulation temperature of buffalo milk added with sodium chloride on quality of reduced-fat paneer. Bev Food Wor, 33: 45-48

Saravanan G and Prakash J, 2004. Effect of garlic (*Allium sativum*) on lipid peroxidation in experimental myocardial infarction in rats. J Ethnopharmacol, 94(1): 155-158, doi: 10.1016/j.jep.2004.04.029

Singh RR, Singh R and Shakya BR, 2014. Impact of turmeric addition on the properties of paneer, prepared from different types of milk. Int J Curr Engi Tech, 4(3): 1874-1883

Snedecor GW and Cochran WG, 2007. Statistical methods. Oxford and IBH

Received- 06.12.2023, Accepted- 22.01.2024, Published- 02.02.2024 (Online), 01.06.2024 (Print)

Section Editor: Dr. I. Samanta, Associate Editor