

Recent developments in safe production of dairy spreads

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Abstract

Dairy spread, a product of spreadable nature, is having a property of plasticity and may or may not be an emulsion in structure. In case of emulsion, it is mostly water-in-oil type. Commonly used spreads are: margarine, cream spreads, butter spreads, cheese spreads, paneer, chakka, yoghurt spreads etc. Compounds such as lecithin, citrates and phosphates play an important role in manufacture of spreads, especially in low fat spreads. Common ingredients used for preparation of dairy spreads are: milk proteins, dried milks, cheese, cream, butter, emulsifiers, colours, preservatives and flavours. Various other ingredients like quinoa, mushrooms, anhydrous milk fat emulsions, maltodextrins, corn extract and oleogels are also being tried to prepare new varieties of spreads. The spreads should have a pseudoplastic character which means the product thins out under the application of force. Whey protein based fat replacers and microparticulated whey proteins enhance the texture of cheese spreads. Innovative spread types like low sodium, antioxidant rich, low fat, probiotic spreads etc. are being developed. Composite spreads with incorporation of millets are also gaining market. Production of nutritionally superior composite spreads using paneer, chhana and chakka by utilizing cereal based products is needed to expand the market potential of traditional Indian dairy products. To enhance the shelf life of dairy spreads, use of biopreservatives along with HACCP system is recommended. Overall it may be stated that the dairy spreads market is set to grow which should be gainfully exploited through the development of newer varieties of dairy spreads keeping in view the consumers' health and convenience.

Key words: Dairy spread, Developments, Functional, Preservation, Probiotic

Highlights

- Most of the fat spreads are structurally water-in-oil emulsion type, and some other spreads are oil-in-water type emulsions.
- Ingredients recently used in spreads are kaki juice, tofu, whey protein isolate, Greek cheese etc.
- In low fat spreads, more liquid oil needs to be used than solid fat.
- Functional spreads using quercetins, phytosterols, grape seed powder, cress seed powder, pumpkin paste, soy cheese, quinoa, mushrooms and probiotic organisms have been developed.
- For good microbial quality, HACCP, hurdle technology and biopreservatives are recommended.

Introduction

Spreads are the food products that are archeologically 'plastic' in nature and can be spread in the form of a thin layer on food items such as bread slice, pizza base, chapati etc. Commonly used spreadable products are margarine, butter and other fat blends. There are some other spreads also in the market which are based on milk fat, other fats of animal, vegetable and marine origin, and blends of milk fat and other fats. Among the spreads, butter (particularly the freshly

prepared ones) is widely consumed by common people. However, butter is relatively expensive, even though it is commercially produced (Varnam and Sutherland, 1994). Of late, there is a tendency among the consumers to avoid butter as a traditional spread for bread mainly due its poor spreadability, high cholesterol and saturated fat contents. Margarines produced using hydrogenated oils have better spreadability, but contains high levels of trans fatty acids which increase

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concentrations of low density lipoprotein (LDL) cholesterol and reduce high density lipoprotein (HDL) cholesterol (Karabulut and Turan, 2006). A large number of spreads of different kinds are available in the market to satisfy the consumers' needs (Varnam and Sutherland, 1994; Panchal and Bhandari, 2020). Liao *et al.* (2020) advocated production of more plant based spreads following the life cycle assessment (LCA) method as these spreads had lower climate, water and land impacts than butter.

Among the spreads, cheese spreads are gaining popularity. In India, production of cheese is increasing at an annual rate of 10-15%, of which about 90% is consumed either as processed cheese or processed cheese spread (PCS). PCS is a good source of protein and fat in pre-digested form and also contains minerals such as calcium and phosphorus, and vitamins like riboflavin and others in concentrated forms. As compared to low fat table spread, PCS contains lower amount of fat, but higher concentrations of proteins, bioactive peptides and conjugated linoleic acid (CLA) (Giri and Kanawjia, 2014). Hence, cheese spread can provide nutritionally superior spread for breads. In general, spreads can very well cater to meet the nutritional requirements of the people. Since spreads are not traditionally used for feeding infants or young children, development of protein rich spreads fortified with iron, vitamins and antioxidants for enhancing nutrition levels of young children was advocated (Briend, 2002; Briend and Solomons, 2003).

A fat spread is an emulsion food (mainly of the water-in-oil type), comprising principally of fats and oils of edible nature, and an aqueous phase while a dairy spread means a spreadable emulsion of water-in-oil type that contains only milk fat in considerable quantity. However, its milk fat content is less than that of butter.

Definition of a dairy spread

According to FAO/WHO (2006), a dairy spread may be defined as follows: "A product,

which is in the form of a solid, malleable emulsion, principally of the water-in-oil type, derived exclusively from milk and/or certain milk products, of which the milk-fat is the essential constituent of value. However, other substances necessary for their manufacture may be added, provided these substances are for the purpose of replacing, either in whole or in part, any milk constituents".

Classification of spreads

Different types of spreads are: Margarine, butter spreads, cream spreads, cheese spreads, paneer spreads, chakka spreads and yoghurt spreads. Fat spreads like margarine, blended fats and butter spreads are water-in-oil type emulsions whereas others are oil-in-water type emulsions. Different categories of spreads are presented in Table 1.

Ingredients for spread manufacture

Table 2 shows the ingredients that are commonly used for the preparation of spreads. Newer ingredients are also being tried by researchers in the manufacture of dairy spreads. The useful properties of different foods can be combined beneficially and used in the manufacture of cheese spreads e.g. health benefits of tofu, stretching property of Mozzarella cheese and flavor of Cheddar cheese (Verma *et al.*, 2013). Olive oil provided good body and texture to chocolate spread while olive oil and butterfat improved the spreadability characteristic of spreads (Kumar, 2015). Kontou *et al.* (2019) indicated that use of olive oil affected flow behavior of cheese spread, but imparted typical flavor. Kaki (*Diospyros kaki*) juice has been used in the preparation of spreadable processed cheese analogue (Abbas *et al.*, 2019). Flax seed oil was used in spreadable processed cheese (Ahmed *et al.*, 2019). Johnson (2019) discussed the importance of low sodium breakfast spreads including dairy spreads. β -glucan from carbohydrate source was used for enrichment of whey protein spread (Zanon *et al.*, 2020). Whey protein isolate (WPI) was used to replace

Table 1. Types and classification of food spreads

Based on source of ingredients		Based on functional attributes		
Dairy spreads: Only milk fat is used		Fortified (fatty acids, vitamins, antioxidants etc.)		
Non-dairy spreads: Vegetable fat with or without milk fat used as a source of fat		Probiotic		
Composite spreads: Dairy ingredients + Non-dairy ingredients				
WHO/IDF		FSSAI		FAO
Dairy spread	Normal: 62 – 80% fat; Reduced fat: 41–61% fat; Low fat: <41% fat	Not more than 80% fat and not less than 40% fat by weight	Milk fat spread	Dairy spread: not less than 60% fat
Blended spread			Mixed fat spread	Reduced fat spread: 60–70% fat
Fat spread			Vegetable fat spread	Low fat spread: 40-60% fat

Table 2. Ingredients for food spreads

Minor ingredients	Major ingredients	
	Water phase	Oil phase
Emulsifier- lecithin, tri-sodium citrates, sodium tripolyphosphates, di-sodium hydrogen phosphates etc.	Protein powders: Milk protein concentrate, whey protein concentrate, rennet casein, acid casein etc.	Fats and oils: Cream, white butter, butter oil, ripened butter, vegetable oils etc.
Flavour -fat and water soluble	Dried milks: Skimmed milk powder, butter milk powder, whey powder etc.	Fat soluble colours and flavors
Colour- fat and water soluble, beta-carotene- fat soluble	Cheese: Cheddar cheese of different age, gouda cheese etc.	
Stabilizers: Alginates, carrageenan, pectin etc.	Salt	
Fortification: vitamins, antioxidants		
Preservatives: Nisin, sorbates, benzoates, butylatedhydroxyanisole, butylatedhydroxytoluene etc.		

the emulsifying salts in processed cheese prepared with acid casein (Solowiej *et al.*, 2020).

Ripened goat cheese was used as raw material for the preparation of spreadable cheese with creamy consistency. Goat cheeses ripened for 10, 20 and 40 days were chosen for the formulation of spreadable processed cheese (Burgos *et al.*, 2020). The product

possessed typical goat cheese flavor. Blend of traditional Greek cheeses i.e. Myzithra, a whey cheese and Feta cheese in the proportion of 0.9/0.1 was used in the preparation of cheese spread by Kontou *et al.* (2019). Salek *et al.* (2020) reported on PCS made by using Chios mastic gum as stabilizer. Recently, cream cheese spread with whey proteins was patented by Wiese and Moca (2020).

Manufacturing process of fat spread

In general, production of fat spreads involves preparation of the water phase and fat phase, emulsion preparation, pasteurization, crystallization, filling and packaging, flow chart of which is shown in Fig.1.

General process of manufacture is: The aqueous phase consisting of water, salt, gums, thickeners, preservatives and water soluble colours is mixed thoroughly with fat phase consisting of oils, emulsifiers and fat soluble colours and the mix is pasteurized at 95°C for no hold. In the next holding tank, flavours are added, mixed and cooled using air blast coolers and finally packaged.

The speed of agitation and time is very important in obtaining desirable consistency in PCS (Černíková *et al.*, 2018). Samples

produced using 3000 rpm were having significantly higher consistency in comparison with the PCS produced using lower agitation speeds (1000 and 1500 rpm). However, the firmness of the product increased during storage at about 6°C.

Manufacture of low fat spread is a technological challenge. A good quality low fat spread can, however, be prepared if suitable emulsifiers and ingredients are used. Since higher levels of water content are available in low fat spreads, an appropriate stabilizer system is needed to impart the necessary stability in the crystallized product. Alginates, pectin and carrageenans have good water binding effect and give stable emulsions. Water-soluble flavours and colours are generally added. To prepare low fat spreads, the water phase and

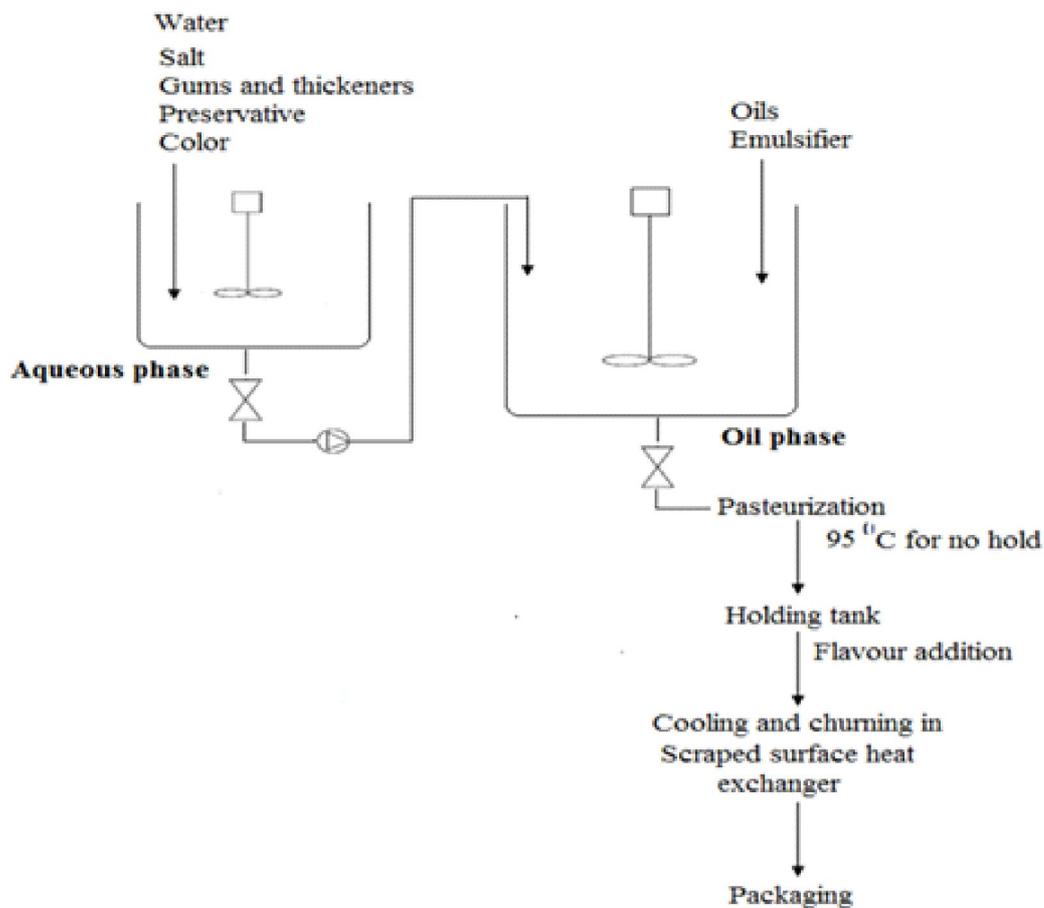


Fig. 1. Schematic diagram of manufacture of vegetable fat spread with venturi system (Source: <https://ecoursesonline.iasri.res.in>)

oil phase having the same temperature are to be mixed slowly to form a proper emulsion and avoid formation of high viscosity. Intensive mechanical treatment tends to build up a higher emulsion viscosity in very low fat spreads, necessitating use of suitably designed stirrers to handle highly viscous emulsions. Anker stirrers function very well in the relatively high viscous emulsions. Storage of spread at a high temperature may render the product soft after cooling, while fast cooling may produce a brittle and more unstable low fat spread. Low fat spreads should be stored at 15°C for 3-5 days before cooling to 5°C. Using storage (G') and loss (G'') moduli within the frequency of 01-100 Hz in a rheometer, the effect of different agitation speeds and various holding times of the melt on the consistency of PCS having 35% dry matter and 40% fat in the dry matter, was examined by Cernikova *et al.* (2017). There was a continuous decrease in firmness of the samples in the first three minutes during holding. Thereafter, the firmness of the samples steadily increased from the third to the twentieth minute of holding time regardless of the speed of agitation tested. All the processed cheese samples showed an increase in firmness over 60 days of storage. To ensure homogeneity, the emulsion needs to be properly blended avoiding incorporation of air during emulsification. It is normally difficult to decrease the fat content to less than about 25% in a spread, if the water droplets have exactly the same size in a water-in-oil emulsion. By utilizing the combined benefits of different emulsifiers, it is, however, possible to create water droplets having different sizes and make the emulsion more closely packed. This also enables to produce 20% - 15% or even 10% fat spreads. Since the oil phase needs to cover a large number of water droplets, it is necessary to have more liquid oil in the fat composition of a low fat spread than similar high fat spreads to preserve the smoothness. Presence of too much palm stearin may render a low fat spread (10% fat) more unstable compared to palm oil probably due to more brittleness during and

after production.

Bascuas *et al.* (2021) claimed that oleogels are viable and healthy alternatives to replace the saturated fat present in chocolate spreads and can be used to replace upto 50% coconut butter in the formulation. The authors designed chocolate spreads using oleogels with two oils (olive and sunflower), hydroxyl propyl methyl cellulose (HPMC) and xanthan gum (XG), as structuring agents. The oleogels conferred consistency to the spreads due to the network formed by HPMC and XG. This concept can have a potential application in dairy spreads. Corn milk, maltodextrin, citric acid and papain were used by Aini *et al.* (2019) to prepare an analogue of low fat cheese spread containing about 7% fat.

Composition of spreads

Composition of spreads as reported by different workers is presented in Table 3.

Table 3. Composition of food spreads

Particular	Range
Moisture	49 - 56%
Fat	60 - 65%
Protein	8 - 10%
Carbohydrate	4 - 6%
Salt	1 - 1.5%

Rheological aspects

Viscosity is a crucial factor during agitation and filling in spread manufacture. Filling should be done in free flow conditions at temperatures higher than 40°C. The structure and rheology of processed cheese are highly affected by the size distribution of the emulsified fat globules and the degree of hydration of the para-casein (Guinee *et al.*, 2004). Understanding the effect of each salt on cheese rheological characteristics (elastic and viscous moduli) is important to obtain the desirable structure in the final product (Cunha *et al.*, 2012). Emulsifiers cause smoother consistency in the spreads. Processed cheese is an oil-in-water emulsion in which dairy proteins play the

important role as emulsifiers. The emulsification potential of caseins is improved by chelating salts which chelate calcium. The active ingredients in the chelating salts are monovalent cations (e.g. sodium) and multivalent anions (e.g. citrate or phosphate). Since calcium influences the three-dimensional structure of rennet casein and cheese, its chelation disrupts the structural integrity and solubilizes casein. The solubilized casein interacts with water and fat on heating and agitation, and forms a gel on cooling (Lee *et al.*, 2004). Therefore, the spreads possess semiliquid to semisolid consistency depending on the type of emulsifier used and behave like pseudo plastic fluids (Lee *et al.*, 2004).

The cheeses manufactured with trisodium citrate, tetra-sodium pyrophosphate, and sodium tri-polyphosphate behaved like concentrated solutions, while those made with sodium hexametaphosphate (SHMP) exhibited the properties of weak gel and lowest values for the phase angle (G'/G''). This means that SHMP cheese had the protein network with the largest amount of molecular interactions as revealed by its high degree of fat emulsification. Citrates, monophosphates and polyphosphates are generally used in the manufacture of processed cheese either in single or combination depending on the properties desired in the products (Berger *et al.*, 1989).

The flow properties of spreads is highly influenced by the ingredients and processing conditions. The processing temperatures for spreads range from 90-98°C. Kontou *et al.* (2019) used 92°C as well as 98°C for processing cheese spreads. Type of ingredients added to the samples affected their flow behavior in various degrees with the olive oil causing the most noticeable changes. The findings of Creep experiments conducted for the flow behaviour of spreads agreed well with those obtained from the elongational flow measurements carried out with the similar samples (Kontou *et al.*, 2019). Smykov *et al.* (2021) did not find any effect of milk obtained from different breeds of cattle on the quality of

butter spread which could be due to the formation of eutectic mixtures of fatty acids during butter manufacture. Use of pumpkin paste up to 15% level enhanced the softness and spreadability of PCS (Kassem *et al.*, 2017).

Developments in low sodium spreads

Content of sodium in processed cheese is usually higher (325-798 mg 50 g⁻¹) than that present in natural cheeses (95-697 mg 50 g⁻¹), mainly due to the addition of NaCl and emulsifying salts (Johnson *et al.*, 2009; Agarwal *et al.*, 2011). The processed cheese industry is, therefore, looking for technological solutions for low salt processed cheese formulations without changing product quality or sensory profile (Mozuraityte *et al.*, 2019). Taylor *et al.* (2018) and Johnson (2019) advocated for the development of low sodium breakfast spreads for better consumer health. Zanon *et al.* (2020) developed a whey protein spread without the addition of NaCl that had similar physicochemical characteristics (pH, viscosity), microbiological counts and sensory acceptance (color, aroma, overall impression) as the products made by using NaCl. The whey protein spread had a shelf life of 28 days at refrigerated temperature and contained 18.67-19.17 g whey proteins, 8.30-8.68 g carbohydrates, 0.2 g fat and 1.56 g lactose per 100 g of the spread. The sensorial results showed that women preferred the product with lower salt content. Use of pumpkin paste up to 15% level reduced the sodium/potassium content in processed cheese which is good for the people suffering from hypertension (Kassem *et al.*, 2017). Ehab *et al.* (2021) stressed on low phosphate containing PCS for diminishing diclofenac-induced hepato-renal injury in male experimental rats.

Microbial quality of spreads

Food spreads pose little health risk from microbes present in them. Spreads are normally stored in domestic refrigerators for quite a few days. This may encourage toxin producing organisms to grow which needs to be

controlled. Highly significant ($p < 0.001$) influence of pH, sorbate, moisture, disodium phosphate and NaCl on the growth of *C. botulinum* in pasteurized reduced sodium cheese products including spreads was observed by Glass *et al.* (2017) in a model study. Even the fat concentration and potassium replacement effects were significant. Results of the study indicated the interaction effect of the ingredients used for spreads preparation.

Use of high-moisture slurries in the production of table spreads may encourage the growth of *Staphylococcus aureus* and *Bacillus cereus*, and subsequent production of heat-stable enterotoxins. Balasubrahmanyam *et al.* (2020) proposed a safety limit of 10^5 CFU/g and highlighted the role of multiple hurdles (pH, potassium sorbate, sodium benzoate, salt etc.) in ensuring microbiological safety of table spreads.

Functional spreads

Demand for spreads fortified with functional ingredients is increasing among the people. Prikryl *et al.* (2018) reported on the preparation of PCS incorporated with rutin or quercetin (phytochemicals). However, processing at 80 – 90°C significantly decreased the quercetin/rutin retention, total phenolic content and antioxidant capacity in the product. Campidelli *et al.* (2020) reported on the bioactive compounds, antioxidants, phenolic compounds, fatty acids and mineral contents in cocoa spread enriched with almonds.

Giri *et al.* (2014, 2017) reported that addition of inulin, phytosterols and ω -3 fatty acid at the rate of 4, 2 and 4 per cent, respectively in PCS showed significant decrease in serum LDL, very low density lipoprotein (VLDL) and atherogenic index in rats model. A large number of dairy and non-dairy functional spreads fortified with biologically active ingredients like omega-3 fatty acids, phytosterols, prebiotics, probiotics etc. have been developed. Renuka *et al.* (2016) developed ω -3 fatty acid fortified PCS using flaxseed oil, algal oil and fish oil emulsions. The authors reported that PCS can be fortified with

flaxseed oil and algal oil up to 15 percent level each and fish oil up to 10 per cent level without significantly altering the product quality.

Lazaro *et al.* (2019) tried to enhance spreadability of butter through emulsification of anhydrous milk fat and high oleic sunflower oils (50:50) in skim milk, and the approach significantly reduced hardness of the spread. However, presence of milk fat was necessary for the survival of probiotic bacteria such as *Bifidobacterium animalis* sub sp. *lactis* Bb-12 during storage at 5°C (Santos *et al.*, 2018).

Frühbauerová *et al.* (2020) enhanced the antioxidant potential of PCS through incorporation of oven-dried and freeze-dried grape skin (FDGS) powder at 1-2% level. PCS samples fortified with FDGS powder had high antioxidant capacity due to the presence of high phenolic compounds.

Mohamed and Hussein (2017) used cress seeds (*Lepidium sativum*) powder at 3.5% level in the manufacture of PCS and reported that the seed powder acted as a good emulsifying agent. Further, the cress seeds incorporated cheese had blood glucose lowering ability in rats indicating its anti-diabetic property. A sweet PCS analogue made by using 10% pumpkin paste was claimed to be suitable for children and patients suffering from hypertension. The pumpkin containing samples also had low sodium and high potassium contents (Kassem *et al.*, 2017).

Analogues

A good quality analogue cheese with high protein content and yield was made from sweet corn extract by adding 20% maltodextrin, 0.2% citric acid and 0.029% papain (Aini *et al.*, 2019). The cheese analogue had 61.59% moisture, 19.83% dissolved protein, 6.97% fat, total dissolved solids of 19.0°Brix, pH of 5.4 and 17.51% yield. The cheese analogue spread from sweet corn extract was yellowish-white in color, easily spreadable and had a distinct cheese aroma without any sour taste, soft texture, and were similar to the cheese made from cow's milk (Aini *et al.*, 2019).

Probiotic dairy spread

Probiotic soy-cheese spread (SCS) was prepared by fermenting soymilk with specific probiotic starter culture followed by processing of the coagulated mass (Giri *et al.*, 2018). SCS samples had 17.6% protein, 25.3% fat and 19.8% total soluble sugar, and more than 10^9 CFU/g of viable probiotic count. It also had significantly higher protein and anti-oxidant activity as compared to commercially available dairy cheese spread. SCS prepared from pure soymilk and from a combination of soymilk and dairy milk, were studied to assess the differences in their rheological behavior during refrigerated storage. The viscoelastic properties of spreads were determined by a dynamic oscillatory test after 0, 7, 14, 21 and 28 days of storage. The storage modulus (G') was higher than the loss modulus (G'') throughout the storage period indicating predominantly elastic behavior of SCS. The cheese spread sample prepared by adding okara to soymilk had the highest values for G' and complex viscosity (1120 Pa and 11.5 Pa s, respectively at an angular frequency of 100 s^{-1}). G' , G'' and viscosity of SCS did not change significantly up to 14 days during storage, thereafter the values increased, which might be an indication of structural changes in the SCS (Giri *et al.*, 2018).

Developments in low fat spreads

Guichard *et al.* (2018) discussed psychology and physiology of fat perception among people to develop low fat spreads with full fat perception. Normally the fat perception is different in different people. Knowledge of the physiological mechanisms controlling fat perception in human beings can lead to a better understanding of the consumer's preference and liking for food emulsions.

Abdeldaiem (2018) compared the quality of reduced fat dairy spreads and reduced fat blended spreads, and reported that the former possessed superior sensory and rheological characteristics as well as stability as compared to the later. Maurya *et al.* (2020) also developed healthy reduced-fat spreads. Reduced fat

cellulose ether emulsions containing 47% anhydrous milk fat (AMF) and 2% cellulose ether were compared with butter and pure AMF. Three types of cellulose ethers were investigated: two methyl celluloses (A4M and MX) and one hydroxypropyl methylcellulose (F4M)). Cellulose ether type affected the crystal network formed and consequently the textural and rheological properties of the emulsions. Presence of cellulose ethers softened the compact structure of the AMF. The physical appearance of all the AMF based emulsions was similar to butter, but with a softer consistency and spreadability at refrigeration and room temperature. The emulsions could be used as spreadable foods or in applications that require plastic properties in spreads.

Ahmed *et al.* (2019) developed spreadable processed cheese to improve nutritional and potential therapeutic value of processed cheese using flaxseed oil to replace up to 75% of fat. The product showed better spreadability, cholesterol lowering ability and assimilability. Based on sensory evaluation, the analogue cheese with 25% of flaxseed oil proved to be best. Contents of total unsaturated fat as well as linoleic, linolenic and arachidonic acids also increased in the product as a result of incorporation of flaxseed oil. The cheese samples with 25% and 50% of flaxseed oil compared well in rheological properties with the control sample. Kamly (2018) added Avicel; a whey protein based fat replacer, in Ras cheese spread to replace 50% of the milk fat. Sánchez-Obando *et al.* (2020) developed a low fat cheese spread with high nutritional value by incorporating microparticulated whey proteins.

Preservation of spreads

Taylor *et al.* (2018) emphasized on the role of sodium against pathogens to make a safe spread. Smigic *et al.* (2018) used nisin at 12.5 ppm level to retard the growth of yeast and mold, and psychrotrophs during storage of cheese spread at refrigeration temperature. The microbial safety of spreads is very important. Conventional techniques and predictive

microbiology models are being used to assess the behavior of microbes in cheese spreads, particularly the growth of pathogens and toxin producing organisms. In modelling studies, *Listeria monocytogenes* has been identified as the main hazard. Other modelling approaches including microbial interaction, growth boundary, response surface methodology and neural networks have also been performed. Validated models have been integrated into user-friendly software tools to obtain estimates of microbial behavior in a quick and easy manner (Possas *et al.*, 2021).

Potential hurdle effect of nisin and sugar alcohol xylitol on indigenous flora and the effect of *pesto* (an Italian pasta sauce made from fresh basil, olive oil and ripened cheese) spreads on the water activity were studied as alternative to traditional pasteurization or acidification treatments. Addition of 4% xylitol and 0.015% nisin (at pH 4.8) to *pesto* spreads (at pH 5.2) resulted in a 0.8 and one log decrease in the total number of bacteria, respectively after 14 days of storage at 4°C. The water activity in the xylitol added spread decreased from 0.886 to 0.864 during the same storage period. The antimicrobial activity of nisin and xylitol was evaluated against *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Bacillus* sp. isolated during the preparation of *pesto* spreads and also against the laboratory cultures of *Listeria innocua* and *Lactobacillus* sp. An additive effect of 0.005% nisin and 5% xylitol on growth inhibition of pure culture of *S. Aureus* was noticed (Culafic *et al.*, 2014).

Mould growth on cheese not only causes deterioration in product quality and poses food safety problem, but also results insignificant economic losses. Normally, a few fungal species such as *Penicillium* and *Aspergillus* sp. dominate on a specific type of cheese. Cheese-contaminating mould species may produce mycotoxins, some of which such as ochratoxin A, cyclopiazonic acid and sterigmatocystin are stable under normal processing conditions. Visible mould growth on cheese in the processing plant should be avoided. To reduce mould contamination of

cheese, preventative measures such as regular cleaning and disinfection of equipment including conveyer belts, vats and production environment are needed. The air in the production facility should have as low level of mould spores as possible. Other preventative measures include strict zonal regulations of the plant, filtration of the air, use of high-pressure air in rooms where the cheese is kept during ripening or just before packaging. Kure and Skaar (2019) recommended a Hazard Analysis Critical Control Point (HACCP) system in a case study. Ammar *et al.* (2017) also reported that PCS produced under HACCP system had lower microbial counts.

Novel ingredients used in the preparation of spreads

Quinoa: El-Dardiry *et al.* (2017) added quinoa paste to PCS to enhance nutritional value by increasing the contents of fibre, protein, ash, salt, soluble nitrogen and total volatile fatty acids. Addition of quinoa paste up to a level of 30% was recommended to reduce the cost of PCS.

Mushrooms: Khider *et al.* (2017) supplemented PCS with fresh and dried mushroom and enhanced its nutritional value.

Epilogue: Among the food spreads, cheese spreads and fat spreads including low fat ones are very popular among the people. Though paneer or chhana based spreads and yoghurt spreads have been developed, their production and consumption are limited. There is thus a need to produce nutritionally superior composite spreads using paneer, chhana, dahi/chakka etc. by utilizing cereal based products.

Conflict of interest: Authors have no conflict of interest in this study.

Author's contribution: KJR: Compiled and collated the published research data and other relevant information and prepared draft of the manuscript; HCD: Helped in drafting the manuscript, revised the manuscript with critical interpretations of data.

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