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Optimization of level of inclusion of prebiotics in cheddar cheese

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Abstract
Cheddar cheese is a hard type of cheese with very good source of nutrients like protein, fat, calories and vitamins to consumer. Cheese with optimum level of prebiotics is known to support the growth of probiotic microorganisms. The objective of the study was to develop cheddar cheese with optimum sensory attributes using different prebiotics. Cheddar cheese without prebiotic was taken as control. Three cheddar cheese samples were prepared by using pectin, inulin and maltodextrin with different levels. Cheddar cheese incorporated with different levels of pectin (T1: 1.5%, T2: 2.0% and T3: 2.5%), inulin (T1: 1.0%, T2: 1.5% and T3: 2.0%) and maltodextrin (T1: 1.5%, T2: 2.0% and T3: 2.5%) were evaluated after 21 days of ripening period at 5 ± 1 °C. Results of the study demonstrated that pectin (2.0 per cent), inulin (1.5 per cent) and maltodextrin (2.0 per cent) showed better flavour, body and texture, finish and overall acceptability without imparting off flavour and discoloration.

Keywords: Cheddar cheese, prebiotics, hydrocolloids, pectin, inulin, maltodextrin

Introduction
Cheeses are gaining more reputation in the world due to their nutritional value, variety in texture and flavour, functionality and its convenient uses. Approximately a third of the world's milk produced is used in cheese manufacturing (Farkye, 2004) [3]. Cheddar is a hard ripened cheese produced by ripening and coagulation followed by partial moisture removal with cheese press. It is highly nourishing and is rich in fat, protein, vitamins and minerals (Murtaza, 2016) [13]. Functional foods are products that have been enriched with added nutrients or other substances that are considered to provide health benefits over and above their nutritional value. The typical examples of functional foods are probiotic yogurts, cholesterol-lowering spreads, and oligosaccharide-added foods (Williamson 2009) [21]. Prebiotics are nonviable food components that exert a benefit on the health of the host, associated with growth of the intestinal flora (FAO/WHO 2007) [4]. Prebiotics were first defined as food ingredients that are non digestible but beneficially affect the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon, helps in improving host health (Mali *et al*. 2020) [11]. Pectin is a hydrocolloid which is anionic in nature, extensively used for its gelling ability and to increase the firmness of dairy products (Soukoulis *et al*. 2008) [16]. Blends of short- and long-chain inulin are capable of modifying sensory properties, especially flavor and texture (Arcia *et al*., 2011) [1]. Saccharides, oligosaccharides and polysaccharides form complexes with proteins and lipids which are known to contribute to the texture of food stuffs and increased body and texture (Tomasik, (2007) [19]. Currently, sensory analysis is considered as a multidisciplinary science structured on scientific principles related to the different areas of knowledge, such as food science, psychology, human physiology, statistics, sociology, psychology, and knowledge about product preparation practices (Stone and Sidel, 2004) [17]. If a product fails to appeal to consumers as a result of any of its sensory characteristics, it will not subsequently be acquired and for this reason the development of methodologies capable of identifying the sensory requirements of consumers is a growing area (Kemp, 2008) [9]. This experimental study thus aims to investigate the acceptability, when incorporated with different levels prebiotics *viz*., pectin, inulin and maltodextrin as an additive, on sensory attributes.

Material and Methods

Procurement of Material: Pasteurized Standardized milk (AAVIN) was purchased from local market of Koduveli, Chennai for the manufacture of cheddar cheese. Freeze dried mesophilic culture (Chr. Hansen's) was used for cheese acidification. Microbial rennet, Fromase® in tablet form was utilized at the rate of 0.01% for cheddar cheese preparation. Pectin ($C_7H_2OO_6$ - 130-260), Inulin $(C_6H_{10}O_5)x$, and Maltodextrin ($C_6nH(10n+2)O(5n+1)$) in powder form were used as prebiotics for cheddar cheese preparation.

Cheddar cheese making protocol

Cheddar cheese was prepared with minor modification of the method as followed by Scott (1981). Milk was heated to 63°C for 30 minutes. It was cooled to 30-31°C and added with 1.0 per cent starter culture. After 30 minutes, renneting was done by addition of microbial Rennet at the rate of 0.01 g for 1 litre of pasteurized milk. The milk was allowed to coagulate (setting) for 45 minutes. Then the curd was cut with cheese knives. The curd mass was cooked to 38-39°C for 45 minutes with slow agitation. The whey was drained out and cheddaring was done at 39 °C. The curd mass was turned every 15 minutes until the acidity increased to 0.45 to 0.50% lactic acid followed by milling of curd mass. Selected levels of prebiotics were added with that of milled curd and salting (1%) was done. It was hooped in cheese moulds, dressed and pressed overnight. The cheese blocks were turned after 8 hours and pressed for 24 hours. After pressing, cheese blocks were removed from press and kept in refrigerator for 2 days for surface drying and then vacuum packed and stored at 5 ± 1 °C.

Sensory analysis

The organoleptic quality of cheese samples were analysed by semi trained panel of 8 judges as per the score card as outlined by NDRI, Karnal. After 21 days of ripening, cheeses were submitted to sensory evaluation. Nine point hedonic scale was used for assessment and the sensory parameters *viz*. flavour, body and texture, finish and appearance and colour were analysed.

Statistical analysis

The data was subjected to statistical analysis in SPSS (version 20.0) software as per the standard procedure outlined by Snedecor and Cochran (1995) [15].

Results and discussion

The mean ± SE values of sensory analysis of cheddar cheese incorporated with different levels of pectin are presented in Table 1. Flavour scores of pectin incorporated cheddar cheese at three different levels (1.5 per cent; 2 per cent and 2.5 per cent) were in the range from 7.58±0.05 to 8.43±0.04 compared to control (7.06±0.07). Body and Texture scores of pectin incorporated cheddar cheese ranged between 7.73±0.04 and 8.60±0.03 compared to control (7.31±0.05). Colour and finish scores of pectin incorporated cheddar cheese were in the range from 7.31±0.06 to 7.33±0.06 compared to control (7.33±0.05) and 7.63±0.06 to 8.28±0.06 when compared to control (7.61±0.04) respectively. The overall acceptability scores of pectin incorporated cheddar cheese ranged from 7.63±0.04 to 8.16±0.06 when compared to control (7.26±0.04).

Table 1: Mean ± SE values of the sensory evaluation of different levels of pectin incorporated cheddar cheese (n=6)

Treatments	Sensory analysis				
	Flavour	Body and Texture	Colour	Finish	Overall Acceptability
Pectin					
C	7.06±0.07^{a}	7.31±0.05^{a}	7.33±0.05	7.61±0.04^{a}	7.26±0.04^{a}
T_1	7.58±0.05^{b}	7.73±0.04^{b}	7.31±0.06	7.63±0.06^{a}	7.63±0.04^{b}
T_2	8.43±0.04^{d}	8.60±0.03^{d}	7.33±0.06	8.28±0.06^{c}	8.16±0.06^{c}
T_3	7.85±0.04^{c}	8.08±0.04^{c}	7.32±0.06	7.85±0.04^{b}	7.76±0.04^{b}
F-value	110.921**	141.956**	1.05^{NS}	33.519**	52.872**

C - Control cheddar cheese
T1 – 1.5% pectin incorporated cheddar cheese
T2 – 2% pectin incorporated cheddar cheese
T3 – 2.5% pectin incorporated cheddar cheese
Means bearing different superscripts within columns (a, b, c, d) differ significantly ($P< 0.05$) (NS- $P > 0.05$; *- $P< 0.05$; **- $P< 0.01$)

The results of pectin incorporation reveals higher flavour scores (8.43±0.04), body and texture scores (8.60±0.03), finish scores (8.28±0.06) and overall acceptability scores (8.16±0.06) at 2 per cent level in cheddar cheese. Analysis of variance revealed a highly significant ($P< 0.01$) difference between groups. The results are in congruence with the findings of Macku *et al*. (2008) [10] who reported that 2% pectin w/w incorporation resulted in significantly better scores in appearance (finish) ($p< 0.05$) compared with other samples of processed cheese and with higher pectin concentrations. Addition of pectin increased Ca reactivity to the dairy desserts that resulted in increased gel strength, critical strain, adhesiveness (Gulzar *et al.*, 2015) [5]. Arltoft *et al.* (2008) [2] opined that pectin addition gave the desserts a significantly altered sensory profile with increased adhesiveness and strongly reduced aqueousness and this resulted in improved body and texture.

The mean ± SE scores of sensory analysis of cheddar cheese incorporated with different levels of inulin are presented in Table 2. The flavour scores of inulin incorporated cheddar cheese at three different levels (1.0 per cent; 1.5 per cent and 2.0 per cent) were in the range from 7.86±0.18 to 8.65±0.04 when compared to control (7.43±0.04). Body and Texture scores of inulin incorporated cheddar cheese were in the range of 8.00±0.05 to 8.86±0.07 when compared to control (7.63±0.04). Colour and finish scores of inulin incorporated cheddar cheese were in the range from 7.54 ± 0.04 to 7.58 ± 0.04 when compared to control (7.56±0.03) and 7.86±0.04 to 8.60±0.04 compared to control (7.85±0.06) respectively. The overall acceptability scores of inulin incorporated cheddar cheese at three different levels were in the range of 7.91±0.04 to 8.48±0.04 when compared to control (7.60±0.03).

Table 2: Mean ± SE values of sensory evaluation of different levels of inulin incorporated cheddar cheese (n=6)

Treatments	Sensory analysis				
	Flavour	Body and Texture	Colour	Finish	Overall Acceptability
Inulin					
C	7.43±0.04^{a}	7.63±0.04^{a}	7.56±0.03	7.85±0.06^{a}	7.60±0.03^{a}
T_1	7.86±0.18^{b}	8.00±0.05^{b}	7.58±0.04	7.86±0.04^{a}	7.91±0.04^{b}
T_2	8.65±0.04^{c}	8.86±0.07^{d}	7.56±0.05	8.60±0.04^{b}	8.48±0.04^{c}
T_3	7.95±0.07^{b}	8.18±0.04^{c}	7.54±0.04	8.01±0.05^{a}	7.96±0.04^{b}
F-value	22.449**	81.259**	1.26^{NS}	43.086**	64.222**

C - Control cheddar cheese
T1 – 1.0% inulin incorporated cheddar cheese
T2 – 1.5% inulin incorporated cheddar cheese
T3 – 2.0% inulin incorporated cheddar cheese
Means bearing different superscripts within columns (a, b, c, d) differ significantly (*P*< 0.05) (NS- P > 0.05; *- *P*< 0.05; **- *P*< 0.01)

The results of inulin incorporation reveals higher flavour scores (8.65±0.04), body and texture scores (8.86±0.07), finish scores (8.60±0.04) and overall acceptability scores (8.48±0.04) at 1.5 per cent level in cheddar cheese. Analysis of variance revealed a highly significant (*P*< 0.01) difference between groups. The results are in accordance with the outcome of Junyusen *et al*. (2017) [8] who opined that the addition of inulin contributed to the improved compositional, textural, micro-structural characteristics of the reduced fat cheese. The findings are consistent with that of research work done by Meyer *et al*. (2011) [12], who reported that inulin contributed to increased porosity in protein matrix network and caused softness to dairy products. According to Tarrega *et al*. (2006) [18], adding inulin to fat-free dairy model desserts increased sweetness, thickness and creaminess and over all acceptability of fat free starch based dairy desserts.

The mean ± SE values of sensory analysis of cheddar cheese incorporated with different levels of maltodextrin are presented in Table 3. Flavour scores of maltodextrin incorporated cheddar cheese at three different levels (1.5 per cent; 2 per cent and 2.5 per cent) were in the range of 7.63±0.06 to 8.41±0.07 when compared to control (7.33±0.04). Body and Texture scores of maltodextrin incorporated cheddar cheese ranged between 7.71±0.04 to 8.60±0.05 when compared to control (7.30±0.02). Colour scores of maltodextrin incorporated cheddar cheese varied from 7.28±0.05 to 7.38±0.03 when compared to control (7.28±0.04). Finish scores of maltodextrin incorporated cheddar cheese were in the range of 7.61±0.07 to 8.31±0.06 when compared to control (7.60±0.03). The overall acceptability scores of maltodextrin incorporated cheddar cheese at three different levels were in the range of 7.63±0.06 to 8.18±0.04 when compared to control (7.33±0.08).

Table 3: Mean ± SE values of the sensory evaluation of different levels of maltodextrin incorporated cheddar cheese (n=6)

Treatments	Sensory analysis				
	Flavour	Body and Texture	Colour	Finish	Overall Acceptability
Maltodextrin					
C	7.33±0.04^{a}	7.30±0.02^{a}	7.28±0.04	7.60±0.03^{a}	7.33±0.08^{a}
T_1	7.63±0.06^{b}	7.71±0.04^{b}	7.28±0.05	7.61±0.07^{a}	7.63±0.06^{b}
T_2	8.41±0.07^{c}	8.60±0.05^{d}	7.38±0.03	8.31±0.06^{b}	8.18±0.04^{c}
T_3	7.78±0.04^{b}	8.01±0.04^{c}	7.30±0.05	7.78±0.06^{a}	7.65±0.04^{b}
F-value	68.899**	151.596**	1.35^{NS}	29.026**	33.333**

C - Control cheddar cheese
T1 – 1.5% maltodextrin incorporated cheddar cheese
T2 – 2.0% maltodextrin incorporated cheddar cheese
T3 – 2.5% maltodextrin incorporated cheddar cheese
Means bearing different superscripts within columns (a, b, c, d) differ significantly (*P*< 0.05) (NS- P > 0.05; *- *P*< 0.05; **- *P*< 0.01)

The results of maltodextrin incorporation shows higher flavour scores (8.41±0.07), body and texture scores (8.60±0.05), finish scores (8.31±0.06) and overall acceptability scores (8.18±0.04) at 2.0 per cent level in cheddar cheese. Analysis of variance revealed a highly significant (*P*< 0.01) difference between groups. The results concurs with the findings of Iakovchenko *et al.* (2016) [7] who also concluded that tapioca added with maltodextrin (1.1%) led to strongest evidence of increased creaminess, smoothness of mouth coating and decrease of firmness of the soft unripened cheese. This specific attribute is due to the maltodextrin creating disruptions in the protein matrix and increased moisture level resulting from the higher water binding capacity of the maltodextrin. Wadhwani (2011) [20] also opined that maltodextrin improved the body and texture score of low fat mozzarella and cheddar cheeses due to the water binding capacity of low molecular weight polymers present in maltodextrin. Hyvonen *et al*. (2003) [6] reported that polydextrose and maltodextrin working as bodying agents in the fat-free ice creams significantly increased flavor release, fattiness, creaminess and melting rate of the ice cream.

Conclusion

The influence of pectin, inulin and maltodextrin with different levels of addition in cheddar cheese was investigated. The pectin, at different level of incorporation (1.5, 2.0 and 2.5 per cent) caused significant difference in sensory attributes *viz*. flavour, finish, body and texture and ultimately improved the overall acceptability. The overall acceptability of inulin samples (1.0, 1.5 and 2.0 per cent) is more with respect to its appearance, flavour and texture than control. Maltodextrin affected positively appearance (finish), texture and overall

preference, but no such effect was found for color especially when added at 2.0 per cent level. It can be concluded from the present study that the optimum level of incorporation based on flavour, body and texture, finish and overall acceptability of prebiotics *viz*. pectin, inulin and maltodextrin for the preparation of prebiotics cheese is 2, 1.5 and 2 percent respectively without imparting off flavour and discoloration.

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