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Effect of combination of hydrocolloid and emulsifiers on micro visco - amylograph, physical and storage qualities of eggless cake

A. Ashwini, D. Indrani and H.N. Ramya

The present study was aimed to investigate the effect of hydrocolloids like gum arabic (AR), guar gum (GR), xanthan gum (XN), carrageenan (CG) and hydroxypropyl methylcellulose (HPMC) were used in combination with emulsifiers such as glycerol monstearate (GMS) and sodium stearoyl-2-lactylate (SSL) on the physical, sensory and storage characteristics of eggless cake was studied. Addition of hydrocolloids to wheat flour as well as in the presence of GMS and SSL increased the eggless cake batter viscosity, specific gravity; in which XN showed the highest value. Among the different hydrocolloids screened, HPMC improved the eggless cake making characteristics of the wheat flour. The overall quality score of eggless cake was increased with HPMC, GMS and SSL. The results indicate that among hydrocolloids used for the study; HPMC brought about highest improvement in eggless cake making characteristics of wheat flour as well eggless cake with GMS and SSL. Effect of combination of hydrocolloid and emulsifiers on storage characteristics of eggless cake was also studied. The moisture content of control eggless cake was 30.8 per cent and eggless cake with the combination of HPMC, GMS and SSL was 33.48 per cent and the moisture content of eggless cake showed not much change during storage for 10 days. It is clear from the results that the texture values of eggless cake with combination at any time of storage were lower than the control eggless cake.

Key Words : Eggless cake, Hydrocolloids, Emulsifiers, Batter viscosity, Texture

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INTRODUCTION

Cake is a bakery product; cake industry has developed rapidly in recent years all over the world. Major ingredients in the preparation of cake mix includes all or some of the following: flour, egg white, or whole egg, milk, sugar, shortening and leavening agents, flavours and other additives (Hussain and Al-Oulabi, 2009).

Egg is a versatile food component; used in the preparation of bakery products, egg proteins serves important functional properties and also aid in improvement of product quality. Functions of egg in cake batter and cake product comprises: emulsifying capacity; leavening action; protein gelation to maintain cake volume and air cell structure; tenderizing and moisturizing effect, provide protein nutrition and helps in overall improvement in eating quality. In spite of these functionalities, application

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of eggs in many food products has got limitations. In specific, the cholesterol content of eggs causes concern. In addition, there are other health issues regarding its saturated fatty acid content, the risk of Salmonella contamination and the availability of bird products in view of a possible outbreak of bird flu. The limited shelf-life, high costs and volatile pricing also make egg a less favoured food ingredient in bakery products. If these are not satisfactory reasons to avoid eggs in a baking recipe, some people refuse to eat eggs because of religion or based on strict vegetarian principles (Kloek *et al.*, 2007 and Ashwini *et al*., 2009). To address these issues, many compositions have been proposed to replace egg source partially or completely.

Milk proteins are widely used as alternative to egg protein in the baking industry. Milk proteins are considered as power house of bioactive peptides, they are known to carry wide range of biological and techno-functional peptides (Naik *et al.*, 2013). Whey proteins contain all the essential amino acids and have the highest protein quality ratings among other proteins. Naik *et al.* (2012) reported that whey proteins has got the better ability to modify the texture, stabilizing emulsions, foams and gels, helps to impart viscosity and water-holding capability and also as a fat mimetic. Hussain and Al-Oulabi (2009) reported a substitute for the egg in cake making by using whey proteins and lupine proteins. Partial replacement of egg white protein with whey protein isolate in angel food cake showed an overall poorer quality, with lower cake volume and coarser bubbles structure, which was probably due to the higher denaturation temperature of whey protein. Efforts were made to improve quality of eggless cake structure using ultrasonically treated whey protein (Tan *et al.*, 2015). Milk proteins could improve cake quality; but considerably at higher cost. Hence, whey proteins were used an alternative ingredient in cake baking.

Miller and Setser (1983), suggested the use of XN to partially replace egg white content in cakes. Glicksman (1991), noted that hydrocolloid contents allow preparation of low-fat cakes with larger volumes and finer uniform cell structure similar to that of cakes with the original shortening levels. Maier *et al*. (1993) suggested that in bakery products, hydrocolloids such as GR and CMC at level of 0.50 per cent flour weight basis were preferred in the formulation to reduce the fat content by 10-20 per cent in muffins and cookies and omitting fat in bread. XN can also be used in soft baked goods for the replacement of egg white content without affecting appearance and taste. It is also used in prepared cake mixes to control rheology and gas entrainment and to impart high baking volume. Solid particles like nuts are prevented from settling during baking (Katzbauer, 1998 and Khan *et al.* 2007). Inigo *et al.* (2001) analyzed the possibility of total substitution of egg proteins in small ratio yellow cakes by optimum leavening agent, emulsifiers, and XN levels in this system. Hydrocolloids in conjunction with proteins are known to be efficient emulsifiers (Garti and Leser, 2001). Most hydrocolloids can act as stabilizing agents of oil-in-water emulsions, but only a few can act as emulsifying agents. The latter functionality requires substantial surface activity at the oil–water interface and hence, the ability to facilitate the formation and stabilization of fine droplets during and after emulsification (Dickinson, 2003 and Dickinson, 2004).

Zambrano *et al.* (2004) reported that gums increase the viscosity of the water phase, can change the foam stability of whipped products and cake batter. Kumari *et al*. (2011) reported that replacement of 60 g of hydrogenated fat with 30 g of oil/ 100 g of wheat flour in pound cake formulation resulted in a decrease in batter viscosity, cake volume and overall quality score. Addition of combination of identified emulsifier and hydrocolloid brought significant improvement in the quality characteristics of cakes with oils. Arabshirazi *et al.* (2012) reported that replacement of XN HPMC with egg separately or at the presence of emulsifiers resulted in an enhancement of water absorption, dough development time, and dough resistance time and calorimetric value. The almost unique foaming, emulsifying and heat coagulation properties of egg proteins confer a very important functional role in the definition of cake characteristics. This makes it extremely difficult to replace eggs successfully by a different source of proteins, even by the use of several types of additives, such as hydrocolloids, in cakes. Hence, the present study was formulated to identify the suitable hydrocolloids and emulsifiers for the improving the characteristics of the eggless cake.

METHODOLOGY

Materials:

Commercial wheat flour obtained from the local market was used for the studies. Flour characteristics moisture, ash, dry gluten, falling number, Zeleny's sedimentation value were determined according to AACC (American Association of Cereal Chemists, 2000) method. Commercially available hydrocolloids such as gum arabic (AR) [EC 232-519-5], xanthan gum (XN) [EC 234-394-2], guar gum (GR) [EC 232-536-8] and carrageenan (CG) [EC 232-524-2] were procured from sigma chemicals, Bangalore, India. Hydroxylpropyl methylcellulose (HPMC) [Methocel-K4M] was procured from Dow Chemical International Pvt. Ltd. Mumbai, India. Emulsifiers like glycerol monostearate (GMS) and sodium stearoyl-2-lactylate (SSL) were procured form Biocon India Pvt. Ltd., Bangalore, India. Sugar was procured from the local marker. Shortening, Margarine, was procured from Hindustan Unilever Ltd., Mumbai, India. Baking powders (single and slow acting type), acid source sodium aluminum sulfate were procured from Hindustan Unilever Ltd. salt, calcium propionate, glacial acetic acid were procured from S. D. Fine Chem Ltd., Mumbai, India., Pineapple essence was procured from Bush Boake Allen., Chennai, India.

Preparation of emulsifier gel:

Gels were prepared using emulsifier and water in the ratio of 1:4. First dispersions were made and then dispersions under continuous agitation were heated to a temperature of 65°C for GMS and 45°for SSL. On cooling gels were obtained. For all the experiments the gels were added in the order that there were 0.5 per cent emulsifiers on wheat flour basis.

Rheological characteristics:

Effect of AR, XN, GR, CG and HPMC separately and in combination with GMS and SSL at the level of 0.5 per cent on amylograph characteristics of wheat flour was studied in triplicate according to AACC method (22-10) using micro-visco amylograph (Model 803201, Brabender, Germany) equipped with 300 mcg sensitivity cartridge. The conditions of the test as follows: wheat flour- 15 g; emulsifier -0.5 g; hydrocolloids-0.5 g; water addition-100 ml; heating rate 7.5°C/min; temperature profile 30-92°C; speed 250/min.

Cake formulation:

The following formulation for the preparation of eggless cake was used; wheat flour 100g; shortening 25 g; sugar powder 80 g; salt 0.25; g baking powder 5.0 g; pineapple essence 0.4 ml; calcium propionate 0.3 g; glacial acetic acid 0.1 ml; water 115 ml; hydrocolloids: AR/XN/GR/CG/HPMC 0.5 g and emulsifier GMS/SSL 0.5 g, wheat flour, salt, baking powder, hydrocolloid and calcium propionate were sifted thrice and sugar powder, margarine and essence were creamed for 1 min at 112 rpm and 5 min at 173 rpm in a Hobart N-50 mixer (Ontario, Canada). Fifty milliliters of water and emulsifier gel were added and mixture was whipped for 1 min at 112 rpm and 2 min at 173 rpm. Finally flour and remaining water were added, mixed at 58 rpm for 1 min, 112 rpm for 1 min and at 173 rpm for 2 min. until homogeneous. The batter temperature was 28°C. Eggless cake batter (450 g) was transferred into a cake pan and baked at 200 C for 60 min using the oven (APV, Queensland, Australia).

Evaluation of cake batter for specific gravity and viscosity:

Specific gravity of eggless cake batter at (28.2°C) was calculated by dividing the weight of a standard measure of the batter by the weight of an equal volume of water. The viscosity of eggless cake batter was determined using a Brookfield viscometer (Model DV-III, Stoughton, MA, USA) according to Kim and Walker (1992), with slight modifications. Cake batter was transferred to a 100 g beaker and leveled upto the brim. The spindle speed was set to 20 rpm and spindle number 7 was used for all experiments. The experiment was run at room temperature (28°C). Viscosity was measured immediately.

Measurement of physical and sensory characteristics of eggless cake :

Cake volume was measured by the rapeseed displacement method (Chopin, S.A., France). Eggless cake crumb firmness was measured using a texture analyzer (Model TAHDI, Stable Microsystem, Surrey, UK). The force required for 25 per cent compression was recorded using the following conditions: sample thickness 1 inch; load cell 5 kg, cross-head speed 100 mm/min, and plunger diameter 35 mm (American Association of Cereal Chemist, 2000). The values reported are the average of four readings.

Statistical analysis:

Data were statistically analyzed by using ANOVA with six experimental groups appropriately to the Completely Randomized Design with four replicates each. The experimental groups were then separated statistically using Duncan's new multiple range tests, as described by Steel and Torrie (1960).

Observations and Assessment

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Quality characteristics of wheat flour :

Chemical characteristics of wheat flour is presented in Table 1. The wheat flour used contained 0.5 per cent ash, 9.7 per cent dry gluten, 480 falling number, 24 sedimentation value, The above characteristics indicate that the wheat flour selected for the studies was of medium strong quality.

Table 1: Chemical characteristics of wheat flour

Parameters	Values
Total ash (%)	0.5
Dry gluten (%)	9.7
Zeleny's sedimentation value	24
Falling number	480

Effect of combination of hydrocolloid and emulsifiers on micro visco - amylograph, physical and storage qualities of eggless cake of eggless cake:

Effect of hydrocolloids on the micro-visco-amylograph characteristics of wheat flour:

The effect of AR, XN, GR, CG and HPMC separately at the level of 0.5 per cent on the amylograph characteristics of wheat flour is shown in the Fig. 1 and Table 2. It is observed that on the addition of hydrocolloids, the gelatinization temperature decreased from 61.7 to 58.6 – 62°C. XN had the least gelatinizing temperature of 58.6°C which means that it can absorb water easily to swell up at a faster rate compared to other hydrocolloids. Peak viscosity representing the ability of the starch granules to swell freely before their physical breakdown increased only with the addition of GR (1050 BU) and all the other hydrocolloids decreased it from 975 to 824 BU. This is mainly due to the interactions between the hydrocolloids and the starch granules. Starch with high swelling power yields maximum viscosity. Increase in the maximum viscosity has been previously observed with the addition of XN (Evans *et al.*, 1977) and also galactomannans like GR (Christianson *et al.*, 1981 and Allonce *et al.*, 1989). It can be concluded from the above results that swelling capacity of starch granules increased in the presence of GR. Hot paste viscosity describing the stability of the already broken starch granules at the cooking temperature, increased with GR (649 BU), HPMC (629 BU) and decreased with the addition of AR (537 BU), CG (568 BU) and XN (568 BU). The cold paste viscosity when compared to control (1173 BU) increased with HPMC (1176BU) and decreased with XN

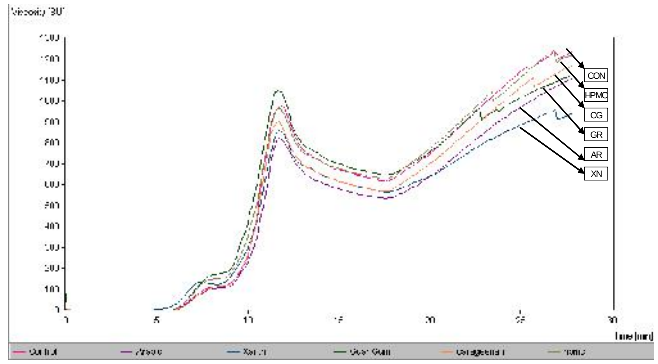


Fig. 1 : Effect of hydrocolloids on the micro visco- amylograph characteristics of wheat flour. (CON: Control; AR: Arabic; XN: Xanthan; GR: Guar; CG: Carrageenan; HPMC: Hydroxy propyl methyl cellulose)

Table 2: Effect of hydrocolloids on the Micro visco - amylograph characteristics of Wheat flour

Parameters	CON	Hydrocolloids (0.5%)				
		AR	XN	GR	CG	HPMC
Gelatinization temp (°C)	61.7	62	58.6	61.1	61.6	60.8
Peak viscosity (BU)	975	824	860	1050	901	965
Hot paste viscosity (BU)	621	537	568	649	568	629
Cold paste viscosity (BU)	1173	1014	917	1050	1073	1176
Breakdown (BU)	354	287	292	401	333	336
Set back (BU)	552	477	349	401	505	547

CON: Control; AR: Arabic; XN: Xanthan; GR: Guar; CG: Carrageenan; HPMC: Hydroxy propyl methyl cellulose

(917 BU), AR (1014 BU), GR (1050 BU) and CG (1073 BU) (Table 2). The breakdown values increased only with the addition GR from 354 to 401 BU and all other hydrocolloids decreased it from 354 to 336-287 BU. The setback values representing the easiness of cooking and tendency to retrograde were noticeably influenced by hydrocolloids. It was observed that AR, XN, GR, CG and HPMC decreased the setback values from 552 to 547-349 BU; indicating use of above hydrocolloids would be beneficial as antistaling agents in the eggless cake making process.

Effect of hydrocolloids and emulsifier on the micro visco – amylograph characteristics of wheat flour:

Effect of hydrocolloids and glycerol monostearate (GMS):

Influence of hydrocolloids on the amylograph characteristics of wheat flour with GMS is presented in Fig. 2 and Table 3. The peak viscosity of wheat flour with GMS was 914 BU and it increased with AR, GR, CG and HPMC from 914 to 954-1044 BU while it decreased from 914 to 889 BU with XN (Table 3). The cold paste viscosity increased from 1130 to 1224 BU and 1142 BU with GR and HPMC, respectively. The breakdown values and set back values decreased with hydrocolloids. In the presence of GMS, XN showed the least breakdown value (283 BU) as against the control (320 BU) and CG showed the lowest set back value (396 BU) when compared to control (536 BU).

Effect of hydrocolloids and sodium steoryl-2-lactylate (SSL):

Influence of hydrocolloids on the amylograph characteristics of wheat flour with SSL is presented in Fig. 3 and Table 4. The results showed that addition of AR increased gelatinization temperature from 61.8 to 62.9°C and CG (63.9°C) while XN and GR decreased it. Among different hydrocolloids, addition of only GR caused an increase in the peak viscosity (1044 BU) and all other hydrocolloids decreased it from 1037 to 992-941 BU. The cold paste viscosity of wheat flour with SSL was 1179 BU and it increased to 1219 BU with XN and

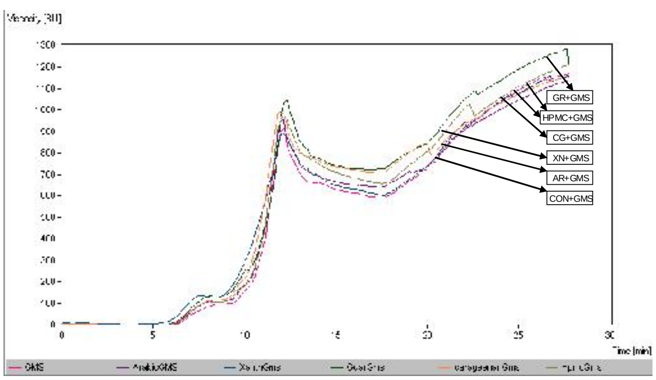


Fig. 2 : Effect of hydrocolloids and glycerol monostearate (GMS) on the micro visco – amylograph characteristics of wheat flour. (CON: Control; AR: Arabic; XN: Xanthan; GR: Guar; CG: Carrageenan; HPMC: Hydroxy propyl methyl cellulose)

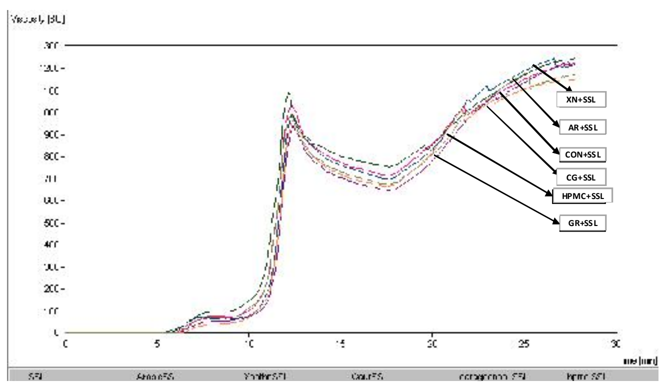


Fig. 3 : Effect of hydrocolloids and sodium steoryl-2-lactylate (SSL) on the micro visco – amylograph characteristics of wheat flour. (CON: Control; AR: Arabic; XN: Xanthan; GR: Guar; CG: Carrageenan; HPMC: Hydroxy propyl methyl cellulose)

Table 3: Effect of hydrocolloids and glycerol monostearate (GMS) on the micro visco amylograph characteristics of wheat flour

Parameters	CON + GMS	Hydrocolloids (0.5%) + GMS (0.5%)				
		AR	XN	GR	CG	HPMC
Gelatinization temp (°C)	62.3	62.2	58.9	61.1	61.8	62.8
Peak viscosity (BU)	914	954	889	1044	991	969
Hot paste viscosity (BU)	594	642	606	725	707	659
Cold paste viscosity (BU)	1130	1074	1116	1224	1103	1142
Breakdown (BU)	320	312	283	319	284	310
Set back (BU)	536	432	510	499	396	483

CON: Control + GMS; AR: Arabic; XN: Xanthan; GR: Guar; CG: Carrageenan; HPMC: Hydroxy propyl methyl cellulose; GMS: Glycerol monostearate

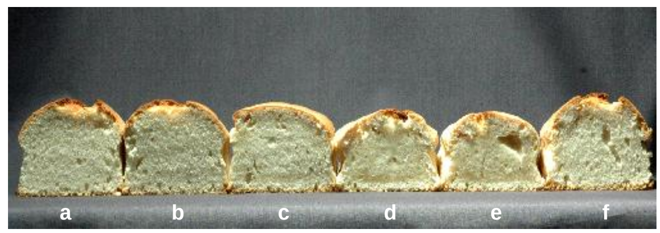
GR (1204 BU) while addition of AR, CG and HPMC decreased it from 1179 to 1173-1126 BU. The breakdown values decreased with addition of AR, XN, CG and HPMC while GR provoked an increased from 319 to 330 BU. The setback values increased from 461 to 522 and 517 BU with AR and XN, respectively while addition of GR decreased the set back from 461 to 445 BU, HPMC (451 BU) while CG did not show any influence. Generally the results showed that addition of hydrocolloids excepting AR decreased gelatinization temperature. The peak viscosity and breakdown increased only with GR. The set back values decreased with hydrocolloids and XN showed the least values.

In wheat flour with GMS use of hydrocolloids except HPMC decreased gelatinization temperature. The peak viscosity increased with hydrocolloids excepting XN, highest peak viscosity was observed with GR. Breakdown values decreased with hydrocolloids. Set back values decreased with hydrocolloids and CG showed the lowest value. In the wheat flour with SSL addition of AR, CG and HPMC increased gelatinization temperature. The peak viscosity increased only with GR. The cold paste viscosity increased only with XN and GR. The breakdown values excepting GR decreased with hydrocolloids. The set back values showed a decrease with GR, CG, HPMC and GR showed the least value.

Effect of hydrocolloids and emulsifiers on the physical characteristics of eggless cake:

Effect of hydrocolloids:

The effect of incorporating hydrocolloids (AR, XN, GR, CG and HPMC) on physical characteristics of eggless cake is presented in the Table 5 and in Fig. 4. The presence of the hydrocolloids increased the batter viscosity at ambient temperature over the control value



(a) Control, (b) Arabic, (c) Xanthan, (d) Guar (e) Carrageenan (f) Hydroxy propylmethyl cellulose

Fig. 4 : Effect of hydrocolloids on the quality of eggless cake

Table 4: Effect of hydrocolloids and sodium steoryl-2-lactylate (SSL) on the micro visco amylograph characteristics of wheat flour

Parameters	CON + SSL	Hydrocolloids (0.5%) + SSL (0.5%)				
		AR	XN	GR	CG	HPMC
Gelatinization temp (°C)	61.8	62.9	58.5	60.1	63.9	62.4
Peak viscosity (BU)	1037	941	993	1089	964	992
Hot paste viscosity (BU)	718	651	702	759	668	679
Cold paste viscosity (BU)	1179	1173	1219	1204	1126	1130
Breakdown (BU)	319	290	291	330	300	313
Set back (BU)	461	522	517	445	462	451

CON: Control + SSL; AR: Arabic; XN: Xanthan; GR: Guar; CG: Carrageenan; HPMC: Hydroxy propyl methyl cellulose;
SSL: Sodium Steaoryl -2- Lactylate

Table 5 : Effect of hydrocolloids on the physical characteristics [a] of eggless cake

HC (0.5 %)	Batter viscosity (Cp)	Batter specific gravity (g/cc)	Moisture (%)	Volume (cm^3 / 450g of batter)	Texture [b] (force, g)
Control	20000a	1.027a	30.3a	730c	740b
AR	24200b	1.036b	30.5a	725c	680a
XN	46400f	1.039c	32.5b	735c	790c
GR	38400e	1.048e	33.0b	580b	1300d
CG	33600c	1.068f	32.6b	500a	1400e
HPMC	35200d	1.043d	33.6b	760d	700a
SEM [C] (±)	4.5	0.001	0.15	15	10

HC: Hydrocolloids; AR: Arabic; XN: Xanthan; GR: Guar; CG: Carrageenan; HPMC: Hydroxy propyl methyl cellulose

[a] Means in the same column followed by different letter differ significantly ($p \leq 0.05$)

[b] Force required for 25% compression measured using texture analyzer

[c] Standard error of the mean at 18 degrees of freedom

from 20000 Cp to 46400 Cp. Among different hydrocolloids XN showed the higher batter viscosity of 46400 Cp followed by GR, HPMC, CG and AR, respectively. This result may be due to xanthan's unique, rod-like conformation, which is more responsive to shear than a random-coil conformation (Urlackern and Noble, 1997). The consistency of batters, like specific gravity, is a very important physical property quality since it represents retain of the small bubbles, which are initially incorporated into the batter during mixing time, lower specific gravity is desired in cake batter since it indicates that more air is incorporated into the batter. Table 5 shows the specific gravity of the cake batter having different hydrocolloids. Control batter had a specific gravity of 1.027 g/cc whereas batter-containing hydrocolloids such as AR, XN, GR, CG and HPMC had a batter specific gravity of 1.036, 1.039, 1.048, 1.068 and 1.043 g/cc, respectively. This indicates that batter with hydrocolloids was heavier and lacks the proper aeration. Among different hydrocolloids tried, only addition of HPMC increased the volume from 730 to 760 cm^3/450g, AR and XN did not show any improvement in the volume while GR and CG decreased it (Fig. 5). This may be explained by the difference in the dielectric properties of different hydrocolloids. According to Gomez *et al.* (2006), the influence of hydrocolloids on the final cake volume is due to increase in batter viscosity that slows down the rate of gas diffusion and allows its retention during the early stages of baking. Shelke *et al.* (1990) suggested that lower viscosity of the batter during heating is one of reason for decreased end product volume. It is possible that, in the presence of a less viscous batter, carbon dioxide evolved and water vapor produced might not be trapped in the air cells during baking, thus resulting in the cakes with low volume. The influence of hydrocolloids on the texture of eggless cake can be observed in Table 5. The presence of HPMC and AR decreased the crumb firmness value from 740 to 700 and 680 g indicating improvement in the texture of cake. Addition of XN, GR and CG increased the crumb firmness value showing adverse effect of them on the texture of cakes. According to Bell (1990), HPMC forms interfacial films at the boundaries of the gas cells that confer some stability to the cells against the gas expansion and processing condition changes. A significant difference was observed in the moisture content when hydrocolloids excepting AR were added, highest moisture content was observed in case of HPMC (33.6%) followed by GR (33 %), CG (32.6%) and XN (32.5%). The increase in the moisture content in eggless cake with HPMC, GR, CG and XN explains the ability of hydrocolloids to hydrate at room temperature; and its self-interactions without competing with gluten proteins and starchy polysaccharides for the water available in the system (Leon *et al.*, 2000).

Effect of hydrocolloids and glycerol mono stearate (GMS):

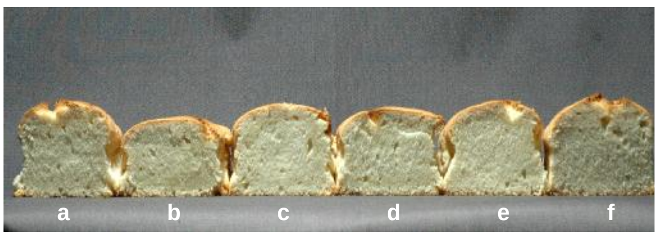
Effect of hydrocolloids on the physical characteristic of cake with GMS is presented in Table 6 and Fig. 5. The results showed that addition of hydrocolloids increased the viscosity of cake batter with GMS, highest increase in the viscosity was observed with XN (51200 Cp) followed by GR (40000 Cp), CG (32000 Cp), AR (30400 Cp) and HPMC (28800 Cp) as against the control with GMS (25600 Cp). However, hydrocolloids like AR, XN and GR when compared to control without any GMS

Table 6 : Effect of hydrocolloids and glycerol monostearate (GMS) on the physical characteristics [a] of eggless cake

HC (0.5 %) + GMS (0.5%)	Batter viscosity (Cp)	Batter specific gravity (g/cc)	Moisture (%)	Volume (cm^3 / 450g of batter)	Texture [b] (force, g)
Control	25600a	1.035a	30.5a	900c	700c
AR	30400c	1.036a	31.3b	680a	970c
XN	51200f	1.039bc	33.2c	925d	670b
GR	40000e	1.038b	33.8c	850b	930d
CG	32000d	1.047e	32.2c	930cd	650b
HPMC	28800b	1.045de	33.6c	950e	600a
SEM [c] (±)	50	0.001	0.25	15	15

HC: Hydrocolloids; AR: Arabic; XN: Xanthan; GR: Guar; CG: Carrageenan; HPMC: Hydroxy propyl methyl cellulose
[a] Means in the same column followed by different letter differ significantly ($p \leq 0.05$)
[b] Force required for 25% compression measured using texture analyzer
[c] Standard error of the mean at 18 degrees of freedom

(Table 5) increased the viscosity while CR and HPMC decreased it. This increase in viscosity might be due to the synergistic interaction between hydrocolloid and emulsifiers in the cake batter as compared to hydrocolloids alone as explained by Turabi *et al.* (2008). The batter specific gravity and moisture content of cakes with GMS also increased with addition of hydrocolloids. The data on volume showed that hydrocolloids like HPMC, CG and XN increased the volume from 900 to 950, 925 and 930 cm^3/450g while AR and GR decreased it from 900 to 680 and 850 cm^3/450g, respectively. The texture of eggless cake with GMS was 700 g and it decreased with addition of XN (670 g), CG (650 g) and HPMC (600 g). The decrease in the texture values due to addition XN, CG and HPMC indicates improvement in the texture of eggless cakes. Addition of AR and GR increased the texture value from 700 to 970 and 930 g indicating adverse effect of AR and GR on the texture of eggless cakes with GMS.

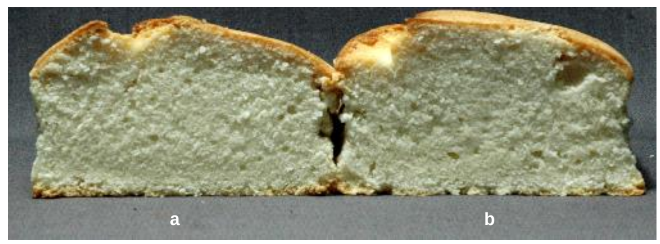


(a) Control, (b) Arabic, (c) Xanthan, (d) Guar (e) Carrageenan (f) Hydroxy propylmethyl cellulose

Fig. 5 : Effect of hydrocolloids and GMS on the quality of eggless cake

Effect of hydrocolloids and sodium steoryl-2-lactylate (SSL) :

Eggless cake making characteristics of wheat flour with SSL and hydrocolloids are presented in Table 7 and in Fig. 6. The results showed that addition of AR, CG and HPMC decreased the batter viscosity of eggless cake



(a) Control, (b) Combination of hydrocolloid and emulsifiers

Fig. 6 : Effect of hydrocolloids and emulsifiers on the quality of eggless cake

Table 7: Effect of hydrocolloids and sodium steoryl-2-lactylate (SSL) on the physical characteristics [a] of cake

HC (0.5 %) + SSL (0.5%)	Batter viscosity (Cp)	Batter specific gravity (g/cc)	Moisture (%)	Volume (cm^3/450g of batter)	Texture [b] (g, force)
Control	32000d	1.029a	30.8a	755a	600e
AR	28800b	1.076f	30.9a	765ab	580cd
XN	43000f	1.061e	31.2b	790c	550ab
GR	36800e	1.034b	33.1c	770ab	580cd
CG	30000 c	1.042c	32.8c	780c	560c
HPMC	28000a	1.051d	33.7c	800cd	530a
SEM [c] (±)	50	0.001	0.15	10	10

HC: Hydrocolloids; AR: Arabic; XN: Xanthan; GR: Guar; CG: Carrageenan; HPMC: Hydroxy propyl methyl cellulose
[a] Means in the same column followed by different letter differ significantly ($p \leq 0.05$)
[b] Force required for 25% compression measured using texture analyzer
[c] Standard error of the mean at 18 degrees of freedom

Table 8: Effect of combination of hydrocolloid and emulsifiers on physical characteristics [a] of cake

Samples	Control	Combination [c]	SEM [d] (±)
Viscosity (Cp)	20000a	24000b	45
Batter specific gravity (g/cc)	1.029a	1.045b	0.001
Moisture (%)	30.4a	33.4b	0.25
Volume (cc)	740a	880b	15
Texture [b] (g, force)	700b	540a	15

[a] Means in the same row followed by different letter differ significantly ($p \leq 0.05$)
[b] Force required for 25% compression measured using texture analyzer
[c] 0.5% Hydroxy propyl methyl cellulose (HPMC) + 0.25%Glycerol Monostearate (GMS) + 0.25% Sodium Stearoyl -2- Lactylate (SSL)
[d] Standard error of the mean at 18 degrees of freedom

with SSL from 32000 to 28800 Cp, 30000Cp and 28000 Cp while XN and GR increased if from 32000 to 43000 and 36800 Cp, respectively. The batter specific gravity and moisture content increased with addition of hydrocolloids, the volume of eggless cake with SSL was 755 cm^3/450g and it increased with addition of AR (760 cm^3/450g), XN (790 cm^3/450g) and HPMC (780 cm^3 / 450g) while addition of GR and CG showed not much change. The texture value with SSL was 600 and it decreased with AR (580 g), XN (550 g), GR (580 g) CG (560 g) and HPMC (530 g). The decrease in the texture value due to addition of hydrocolloids indicates improvement in the texture of eggless cakes. The improvement brought about by HPMC in the presence of SSL was highest.

Effect of combination of hydrocolloid and emulsifiers:

Influence of combination of 0.5 per cent HPMC, 0.25 per cent GMS and 0.25 per cent SSL on the physical characteristics of eggless cake is presented in Table 8 and photographs in Fig. 6. The results showed that addition of HPMC, GMS and SSL increased the viscosity from 20000 to 24000 Cp, batter specific gravity from 1.029 to 1.045 g /cc, moisture from 30.4 to 33.4 per cent, volume from 740 to 880 cc and decreased texture from 700 to 540 g.

Effect of combination of hydrocolloid and emulsifiers on storage characteristics of eggless cake:

Effect of combination of HPMC, GMS and SSL on the storage characteristics of eggless cake is presented in the Table 8 and Fig. 7 and 8. The moisture content of control eggless cake was 30.8 per cent and eggless cake with the combination of HPMC, GMS and SSL was 33.48 per cent. The moisture content of eggless cake showed not much change during storage for 10 days. It is clear from the results that the control eggless cake had a texture value of 700 g at first day when compared to 540 g for eggless cake with combination. The lower texture value for eggless cake with combination shows that the eggless cakes were softer than control. During 10 days storage the texture value increased from 700 g to 1378 g for control and from 540 to 1123 g for eggless cake with combination. The texture values of eggless cake with combination at any time of storage were lower than the control eggless cake.

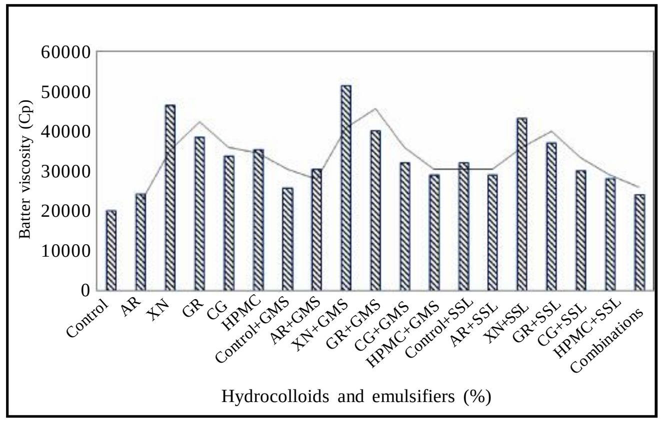


Fig. 7 : Effect of hydrocolloid and emulsifiers on the batter viscosity of eggless cake. AR: Arabic; XN: Xanthan; GR:Guar; CG: Carrageenan; HPMC: Hydroxy propyl methyl cellulose; GMS: Glycerol Monostearate; SSL: Sodium steoryl-2-lactylate; Combination: 0.5% HPMC+ 0.25%GMS+0.25% SSL

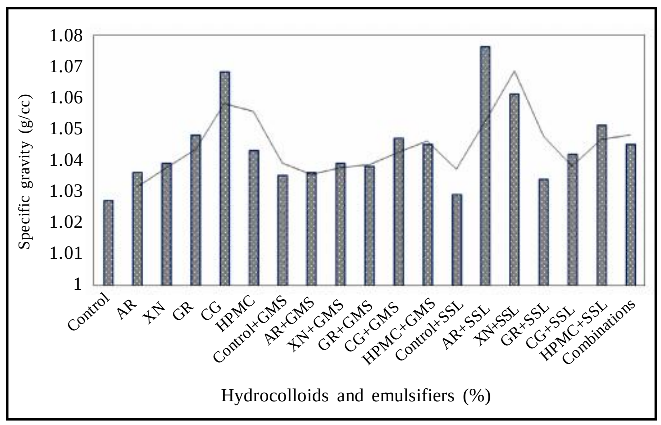


Fig. 8: Effect of hydrocolloid and emulsifiers on the batter specific gravity of eggless cake. AR: Arabic; XN: Xanthan; GR: Guar; CG: Carrageenan; HPMC: Hydroxy propyl methyl cellulose; GMS: Glycerol Monostearate; SSL: Sodium Steoryl-2-lactylate; Combination: 0.5% HPMC+0.25%GMS+0.25% SSL

Conclusion:

Addition of hydrocolloids except AR decreased gelatinization temperature. The peak viscosity increased with GR and all other decreased it. The set back decreased with hydrocolloids and XN showed the least value. Addition of hydrocolloids to wheat flour with GMS excepting HPMC decreased gelatinization temperature. The peak viscosity increased with hydrocolloids excepting XN. The setback decreased with hydrocolloids and GMS and CG showed the least value. Addition of AR, CG and HPMC to wheat flour with SSL increased gelatinization temperature. The peak viscosity increased only with GR and SSL and all other hydrocolloids decreased it. The setback value decreased with GR, CG and HPMC in the presence of SSL. Addition of hydrocolloids increased the batter viscosity and XN showed the highest batter viscosity. Batter specific gravity and moisture were also increased. Among different hydrocolloids tried, HPMC improved the quality of eggless cake. Addition of HPMC increased the overall quality of eggless cake with GMS to the maximum extent followed in decreasing order by CG and XN. Addition of all the hydrocolloids increased the overall quality of eggless cake with SSL and highest improvement was brought about by HPMC. Combination of HPMC, GMS and SSL not only improved the quality of eggless cake but also retained softness during storage.

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