

Research Article

Effect of Different Bicarbonates as Leavening Agents in Combination on Product Characteristics of Cookies and Cake

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Abstract

The increasing importance of convenience in consumer food choices has attracted researchers' interest. Leavening agents are widely used in the preparation of convenience food items. This investigation was undertaken to evaluate the effect of different leavening agents i.e. sodium, potassium or ammonium bicarbonate in combination at varying levels (1.05, 1.10 and 1.15) with acid calcium phosphate (1.4 and 1.5%) on the quality of cookies and cakes. Results showed that combination of sodium and potassium bicarbonate, sodium and ammonium bicarbonate, potassium and ammonium bicarbonate at 1.10% along with 1.4% acid calcium phosphate produce the cookies, and cakes with improved quality. Cookies yield highest W/T value (1.24), top scores (3.35) and overall acceptability scores (7.25) with sodium and potassium bicarbonate at 1.10% levels with 1.4% ACP, as compared to other leavening agents like sodium and ammonium bicarbonate, potassium and ammonium bicarbonate and 1.5% ACP. Similarly, cake also got highest volume and overall acceptability scores with 1.10% of sodium and potassium bicarbonate and 1.14% ACP.

Keywords: leavening agents, acid calcium phosphate, cookies, cake, sensory quality

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Introduction

Chemical leavening agents in the form of different bicarbonates have a best known uses and application in baked goods. Carbon dioxide (CO₂) gas is released when bicarbonate chemicals are assorted and reacted with an acid in the presence of heat. The release of air and carbon released during the reaction causes aeration and allow the batter and dough to rise. This aeration of the dough helps in preparation of making for lighter chemically leavened baked goods such as biscuits, cakes, pancakes and cookies [1]. The word "Leavening" is derived from Latin word *levare* "to raise" and means raising or making light [2]. Chemical leavening system had been known since the first baking powder was formulated in 1938 in England [3].

Self-rising flours, baking powders and pre-packed baking mixes are also made up of an vital ingredient known as bicarbonates that includes sodium, potassium or ammonium bicarbonates. In chemically leavened products bicarbonates reacted with leavening acid to produce CO₂ gas [1]. During baking, CO₂ in the dough expand, producing the "raising" associated with leavening and imparting specific characteristics to the final product [4]. There are three stages during which baked goods shows leavening effect by the action of chemical leavening agents. First one is during the mixing of flour with water and leavening agents. Second one comes when dough and product was allowed to proof prior to baking and the third and final leavening occurs in the course of baking of the product. During baking carbon dioxide gas is released producing the leavening action throughout the dough and this results in establishment of grain structure on the surface of dough prior to that product was set for baking [1]

In general leavening is considered to be a process whereby CO₂ is incorporated into better or dough and then expand upon heating. During baking, by the action of saturated steam from water and hot air, ammonia gas is also produced beyond carbon dioxide gas which plays a significant role in the expansion of dough when it is baked as they have been incorporated during mixing. There are two basic types of chemical leavening – decomposition and chemical neutralization. In decomposition, the chemical leavening agents are split down in presence of water or high temperature and acquire place to provide leavening gas to the system. In neutralization system, bicarbonate chemical

are counterbalanced by presence of an acid like acid calcium phosphate. Studied reported that every carbonate leavening chemical acids had their own distinct phase of gas releasing and degree of reaction. They reported that the rate at which protons are released from the acid is associated with the rate at which carbon dioxide is produced and it becomes available to interact with chemical bicarbonates [5].

Optimum baking leavening agents and system or the form in which they have to be used should be selected by the baking professional on the basis of the final product quality requirement such as desired taste, texture and colour. Combination of leavening acid such as acid calcium phosphate with potential bicarbonate chemical primarily determine the extent and rate of reaction for optimum leavening effect. Studies reported that acid calcium phosphate a fast acting acid when reacts with bicarbonates will results in liberation of as much as 80% of leavening carbon dioxide gas during dough handling and proofing [1]. Combinations of different bicarbonate with different levels of acids will results in release of leavening gases of different profiles which will be appropriate for different bakery products. Attributes of the product, such as color, flavour, texture and overall acceptability are influenced by the reactions between leavening agents, acids and flour components. The choice of bicarbonate used, and acids levels can influence the physical and chemical characteristics of the product [1], [4]. Therefore, the present study was carried out investigate the consequence of different levels leavening agents in combination along with different levels of acid calcium phosphate on the quality characteristics of cookies and cake. Also, to find the best combination level of leavening agents with best level of acid calcium phosphate with improved product quality.

Materials and methods

Refined wheat flour, along with bakery shortening, sodium chloride (table salt), powder sugar, low fat skim milk powder are procured from the local grocery stores, Ludhiana. Different bicarbonates such as sodium, potassium and ammonium bicarbonate and acid calcium phosphate are purchased from the local market of Ludhiana, India.

Formulation of self rising flour

Different leavening agents such as sodium bicarbonate, potassium bicarbonate and ammonium bicarbonate are mixed with refined flour in different combinations (sodium and potassium bicarbonate, sodium and ammonium bicarbonate, potassium and ammonium bicarbonate) with each other at different levels of 1.05(55:50), 1.10 (55:55) and 1.15 (55:60) per cent. The acid was also added to the dry mix at two different levels of 1.4 and 1.5 % acid calcium phosphate (ACP). The contents were then mixed and sifted to obtain uniform mixing and distribution of leavening agents throughout dry flour mix.

Preparation of bakery products

Bakery products such as cookies and cake were made in the laboratory as per standard procedures. The recipe for the ingredients was given in **Table 1** and flow sheet for product preparation was given in **Figure 1** and **2** for cookies and cake respectively. Bakery products i.e. cake was prepared in accordance with the standard procedures of AOAC [6]. For cake baking, fat and sugar was whipped in Horbart mixer at high speed for 4 min followed by addition of egg along with whipping for 1 min. After that sieved flour and essence were added and contents were mixes at low speed. Batter in then poured into greased pan and baked at 400°F for 25 min. For cookies, flour and mixed with ingredients and kneaded to form dough which was then sheeted and cut into circular shapes and baked at 205 °C. After baking, both cake and cookies were allowed to cool down at room temperature (25±2°C) and then packed until used for evaluation.

Evaluation of product quality

Top grain

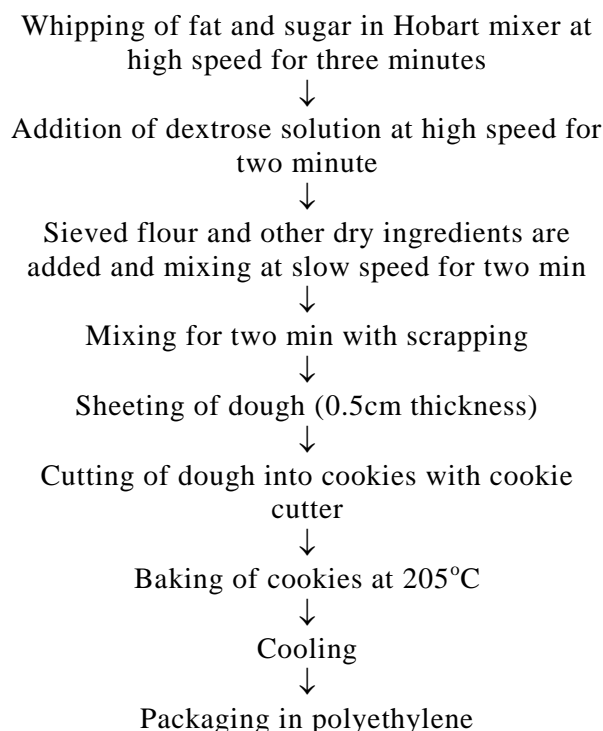
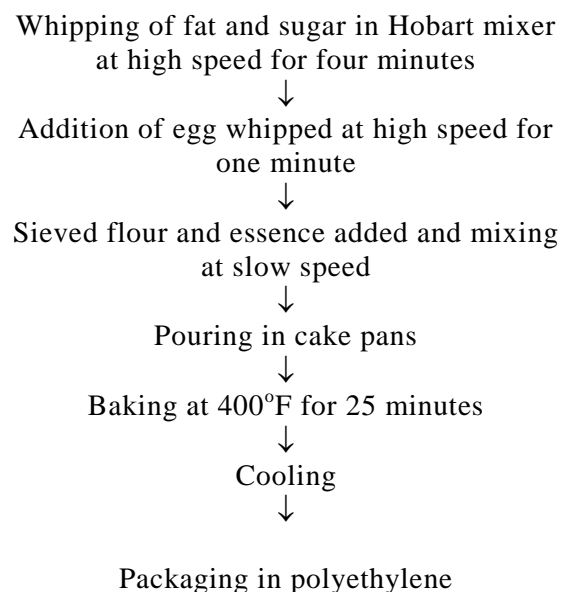
Cookies were evaluated for their top grain score as per method of Vratanine and Zabik [7].

W/T ratio

The thickness and width of six cookies was measures using standard procedure and then expressed as W/T ratio.

Table 1 Recipe for preparation of cookies and cake

Ingredients	Amount (g)	
	Cookies	Cake
Flour	90	100
Sugar	52	140
Shortenings	90	50
Non fat dry milk	12	12
Albumin (egg white)	71	71
Salt	0.84	3
Dextrose Solution (ml)	13.2	-
Distilled water (ml)	64	-
Vanilla essence		0.5
Leavening agents	As described in self rinsing flour preparation	

**Figure 1** Flow chart for cookies making**Figure 2** Flow chart for cake making

Volume and specific volume

Cake prepared was analyzed for weight, volume and specific volume respectively as per standard methods.

Sensory evaluation

Prepared products were subjected to sensory evaluation by a panel of semi trained judges on a nine point hedonic scale and overall acceptability scores was recorded [8].

Statistical analysis

All the data was mean of three observations. The data collected on different characteristics were analyzed statistically with the help of factorial design in CRD with one way ANOVA.

Results and Discussion

Effect of different levels of NaHCO₃:KHCO₃ with acid calcium phosphate (ACP) as leavening agent on product characteristics

Data for cookies prepared from flour containing combination of sodium and potassium bicarbonate (1.05, 1.10, and 1.15 per cent) plus ACP at varying levels was presented in **Table 2**. Results showed that cookies prepared from 1.10% level of combination had spread factor (W/T) significantly higher (1.24) as compared to 1.05 and 1.15 per cent level of sodium bicarbonate and potassium bicarbonate in combination. Cookie top cracks were better for 1.10% level with top score value 3.20. Similarly, acceptability score (7.10) was also significantly better for cookies prepared from flour sample containing 1.10% level of combination because of higher values for colour, texture, taste and flavour. Same trend was also followed by the cookies prepared from flour containing 1.4% ACP with same levels of sodium and potassium bicarbonate combination. Highest scores for spread ratio were observed in the sample which is prepared from flour 1.10% of leavening agents in combination, however effect was non-significant. Significant effect was observed for top score value which was 3.35 at 1.10% level. According to sensory scores for all attributes indicated that 1.10% level flour was best with respect to cookie quality with overall acceptability score 7.25. While comparing the values of 1.5 and 1.4 per cent ACP for cookie quality, flour sample containing 1.4 per cent acid calcium phosphate gives high quality cookies. Singh et al [9] observed that when sodium and potassium bicarbonates are used singly at 1.10% with acid calcium phosphate at 1.4%, cookies shows highest top grain score, spread factor and overall acceptability scores. Brose and Becker [10] also reported that different chemical leavening agents help to improve the product quality.

Cake characteristics (volume, internal score and sensory attributes), were not significantly affected by levels of leavening agents in combination (Table 2). However, sample containing leavening agent in combination at 1.10 per cent level and 1.4 per cent acid calcium phosphate had better score for cake volume and acceptability. Non-significant variations were observed in cakes with respect to volume (cc) baked from three flour samples with 1.05, 1.10, 1.15 per cent of leavening agents in combination. However, the volume (675.1) was greater at 1.10% level of combination with 1.5% ACP. Crumb and crust characteristics were better for muffins produced from flour sample containing 1.10% level of combination with internal score value of 86.75. Similarly, values for mean acceptability score at 1.05, 1.10 and 1.15 per cent level were 7.53, 7.64 and 7.61, respectively. Similar trend was also observed in the flour samples with 1.05, 1.10, 1.15 per cent of leavening agents in combination plus 1.4% ACP. However, 1.4% ACP containing flour sample resulted in better quality cakes as inferred from overall acceptability score which was 7.64 and 7.81 for 1.4 and 1.5 per cent ACP, at 1.10 flour containing combination of sodium and potassium bicarbonate, respectively. Therefore, maximum values were observed at 1.10% values were observed at 1.10% levels of leavening agents in combination with 1.5 per cent ACP.

Table 2 Effect of different levels of NaHCO₃ and KHCO₃ in combination with ACP on quality of bakery products

Product Characteristics	NaHCO ₃ :KHCO ₃ + 1.5% ACP				NaHCO ₃ :KHCO ₃ + 1.4% ACP			
	1.05 (%)	1.10 (%)	1.15 (%)	CD (p>0.05)	1.05 (%)	1.10 (%)	1.15 (%)	CD (p>0.05)
Cookie								
W/T	1.14	1.24	1.23	0.064	1.22	1.24	1.24	NS
Top Score*	2.60	3.20	2.70	0.45	2.80	3.35	3.30	0.32
Overall Acceptability	6.64	7.10	6.99	0.26	6.88	7.25	7.14	0.078
Cake								
Volume(cc)	668.5	675.1	673.5	NS	671.5	678.5	677.5	4.70
Evaluation Score**	86.0	86.75	86.50	NS	88.0	89.5	89.25	NS
Overall Acceptability	7.53	7.64	7.61	0.078	7.67	7.81	7.76	0.079

Score out of 9.0, *Score out of 4.0 ** Score out of 100, ACP: Acid calcium phosphate

Effect of different levels of $\text{NaHCO}_3\text{:NH}_4\text{CO}_3$ with acid calcium phosphate (ACP) as leavening agent on product characteristics

Non-significant variations were observed for spread factor and top score values, but significant effect in case of acceptability was observed in cookies with varying levels of sodium bicarbonate and ammonium bicarbonate as leavening agents with 1.5 per cent ACP (**Table 3**). Maximum spread factor (1.21) was found for cookies prepared from flour containing 1.10% of combination ($\text{NaHCO}_3\text{:NH}_4\text{HCO}_3$) and 1.5% ACP. Similarly, better top score was given to cookies prepared from 1.10% level of leavening agents (2.80). Same pattern was followed by all sensory attributes, in which significantly highest overall acceptability score of 6.96 was obtained when different bicarbonate in combination are used at level of 1.10%. Cookies made from same levels of above combination and 1.4% ACP had non-significant effect on spread factor, however, cookies spread was more with 1.10% level of combination which was 1.22. Similarly, non-significant effect was recorded in top score values but score was maximum at 1.10% level (3.0). Among different levels of leavening agents, cookies with 1.10% level of combination had better acceptability score followed by 1.15% level due to higher colour, texture, taste and flavour scores. When 1.10 per cent of sodium bicarbonate and ammonium bicarbonate in combination with 1.4 per cent acid calcium phosphate was used, cookies shows highest top grain score, spread factor and overall acceptability scores as compared to those prepared at 1.00, 1.05, 1.15, 1.20 and 1.25% [9].

Table 3 Effect of different levels of NaHCO_3 and NH_4CO_3 in combination with ACP on quality of bakery products

Product Characteristics	$\text{NaHCO}_3\text{:NH}_4\text{CO}_3 + 1.5\% \text{ ACP}$				$\text{NaHCO}_3\text{:NH}_4\text{CO}_3 + 1.4\% \text{ ACP}$			
	1.05 (%)	1.10 (%)	1.15 (%)	CD (p>0.05)	1.05 (%)	1.10 (%)	1.15 (%)	CD (p>0.05)
Cookie								
W/T	1.15	1.21	1.20	NS	1.20	1.22	1.21	NS
Top Score*	2.85	2.80	2.60	NS	2.73	3.00	2.98	NS
Overall acceptability	6.38	6.96	6.85	0.15	7.76	7.10	7.01	NS
Cake								
Volume(cc)	0.91	0.96	0.94	NS	0.97	1.01	1.00	NS
Evaluation Score**	84.0	86.0	85.0	NS	84.5	86.5	86.25	NS
Overall acceptability	7.12	7.31	7.26	0.078	7.54	7.68	7.64	NS

Score out of 9.0, * Score out of 4.0, ** Score out of 100, ACP: Acid calcium phosphate

The effect of leavening agents having varying levels of ammonium bicarbonate in combination with sodium bicarbonate with ACP at 1.5 and 1.4 per cent levels for cake quality depicted the similar pattern as for cookies (Table 3). Cakes prepared by using flour containing 1.10 per cent level of combination with 1.5 per cent acid calcium phosphate had better quality (Table 3) having high volume score of 672.5cc. Evaluation score (86.0) also indicated the better quality cakes at same level. Overall acceptability score at 1.05, 1.10 and 1.15 per cent level was 7.21, 7.31 and 7.26, respectively. The values for cake characteristics prepared from flour of same levels of combination and 1.4% ACP showed that that volume, internal scores and acceptability scores were higher for cakes belonging to 1.10% level of combination. Higher cake volume was produced from 1.10% level of leavening agents in combination in flour, however the effect was non-significant. Cake volume of 672.5cc was observed when ACP level at 1.5% was used, however when level of ACP was lowered to 1.4% the volume scores for cake were 675.5cc. Similar observation was recorded for visual evaluation score, while overall acceptability score was significantly differed and maximum (7.68) for cakes baked from flour sample having 1.10% level of combination followed by 1.15 and 1.05% level of combination and 1.4% ACP. The overall acceptability scores were slightly lower at 1.5% ACP with same levels of leavening agents in combination. The highest scores were observed at 1.10% followed by 1.15 and 1.05%

Effect of different levels of $\text{KHCO}_3\text{:NH}_4\text{CO}_3$ with acid calcium phosphate (ACP) as leavening agent on product characteristics

As observed in other combinations of leavening agents as described earlier, the potassium and ammonium bicarbonate as leavening agents at 1.10% level contributed better baking quality as compared to less or more than this level (**Table 4**). Cookies had higher top score (2.7) and acceptability score (6.93) at 1.10% $\text{KHCO}_3\text{:NH}_4\text{CO}_3$ at 1.5% ACP.

But when compared with lesser level of ACP i.e. 1.4%, Cookies were obtained with higher top score (3.0) and acceptability score (7.10) (Table 4). Similarly, all cake characteristics were improved for flour containing 1.10% level of combination and 1.5% ACP as represented by table values. Cookies shows highest top grain score, spread factor and overall acceptability scores when prepared with 1.10 per cent potassium bicarbonate and ammonium bicarbonate in combination with and 1.4 per cent acid calcium phosphate [9].

Table 4 Effect of different levels of KHCO_3 and NH_4CO_3 in combination with ACP on quality of bakery products

Product Characteristics	$\text{KHCO}_3:\text{NH}_4\text{CO}_3 + 1.5\% \text{ ACP}$				$\text{KHCO}_3:\text{NH}_4\text{CO}_3 + 1.4\% \text{ ACP}$			
	1.05 (%)	1.10 (%)	1.15 (%)	CD ($p>0.05$)	1.05 (%)	1.10 (%)	1.15 (%)	CD ($p>0.05$)
Cookie								
W/T	1.14	1.21	1.20	NS	1.19	1.22	1.21	NS
Top Score*	2.20	2.70	2.50	0.19	2.70	3.00	2.90	NS
Overall acceptability	6.29	6.93	6.76	0.11	6.63	7.00	6.91	0.27
Cake								
Volume(cc)	659.0	670.0	668.0	4.52	660.0	671.0	669.0	4.52
Evaluation Score**	75.50	83.5	81.5	0.23	80.0	85.5	83.5	2.61
Overall acceptability	6.71	7.31	7.22	0.06	6.84	7.39	7.25	0.14
Score out of 9.0, * Score out of 4.0, ** Score out of 100, ACP: Acid calcium phosphate								

Similar results were recorded for cakes as in case of cookies. Not much variation was found with respect to specific volume and evaluation score among different levels of leavening agents in combination (Table 4). Cake volume (671.0 cc) was significantly higher for flour containing 1.10% level of leavening agents with 1.4% ACP followed by 1.15 and 1.05% levels of leavening agents in combination. Increase in level of ACP to 1.5% slightly reduced the cake volume to 670.0 at 1.10%, 659.0 at 1.05% and 668.0 at 1.15% levels of $\text{KHCO}_3:\text{NH}_4\text{CO}_3$ in combination. Crust and crumb characteristics for cakes were better where leavening agents added at 1.10%. The mean values of overall acceptability score at 1.05, 1.10 and 1.15 per cent levels with 1.5% ACP were 6.71, 7.31 and 7.22, respectively. Trend of quality remained same when less amount of ACP (1.4%) was added and the overall acceptability scores were 6.84, 7.39 and 7.25. But quality improved as inferred from values of volume, evaluation and acceptability score which were 671cc, 85.5 and 7.39, respectively.

Conclusion

Different bicarbonates as leavening agents in combination i.e. sodium and potassium bicarbonate, sodium and ammonium bicarbonate, potassium and ammonium bicarbonate were used at 1.05, 1.10 and 1.15 per cent levels in the preparation of self raising flour and quality of bakery products prepared from the flour was evaluated. Results showed that different leavening agents in combination at 1.10 per cent with 1.4 per cent ACP produce better quality of cookies and as compared to others levels of bicarbonates as leavening agents in combination and 1.5 per cent ACP. However, from different combination of bicarbonates ($\text{NaHCO}_3:\text{KHCO}_3$, $\text{NaHCO}_3:\text{NH}_4\text{CO}_3$, $\text{KHCO}_3:\text{NH}_4\text{CO}_3$) i.e. leavening agents at 1.10 per cent with 1.4 per cent ACP, combination of sodium and ammonium bicarbonate yield the bakery products with high W/T ratio, top scores, volume, evaluation scores and overall acceptability. Hence it can be concluded that bicarbonates in combination with 1.4% levels of ACP can be used to prepare self raising flour for bakery products delivering better product characteristics.

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