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Influence of Air Incorporation Methods on Physiochemical Properties of Wheat/Corn – Plain Cakes

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Abstract

Flour from wheat (*Trisicum compectum*) and corn (*Zea mays*) grains were produced, then analyzed chemically and blended in the ratios wheat: Corn: 100:0; 80:20; 70:30, 60:40; 50:50 and 0:100%. Plain cakes were produced from these flour blends using various air incorporation methods involving electric mixer, baking powder, air pump and their combinations. The cakes produced were subjected to proximate, physical and sensory analysis The result showed that protein content of flours samples ranged between 8.24% - 11.47%, while carbohydrate were between 70.38% - 76.40%. The fat, moisture, protein, ash and crude fiber of 100% wheat cake differed from those of other blends. Carbohydrate of the cake varies between 60.15% - 63.42% as an indication of high energy product. The cake volume was 355.6.3 cm^3 with the use of electric mixer + baking powder, while air pump method also increased cakes volume to 226cm^3. The densities of 100% wheat cake and 80%:20% blend produced by electric mixer + baking powder did not differ (1.08: 1.06g/cm^3), there were differences in the physical properties of cakes based on different air incorporation methods. .This work suggest that air pump method can replaced baking powders in plain cake making and that substitution of wheat can reach 40%.

Keywords: cake, wheat substitution, air incorporation, proximate composition, physical prosperities.

INTRODUCTION

During ceremonial occasions especially wedding anniversaries and birth- days, cake is the desert of choice. The cake comprising of flour, a binding agent, a sweetening agent, fats, liquid, leavening agent and flavor(Okaka,1997), has been extensively researched on, to improve quality and to meet the nutritional and social needs of consumers. The unique nature of wheat in terms of gluten content has made it the most accepted in bakery products (Potter and Hotchkiss, 1995). Unfortunately over dependence on this crop has made it too expensive for non producers.

The search for alternative or possible substitution must continue to go on, and this substitution must meet the quality need of the consumers. Cakes are assessed by mouth and hand fell, this is achieved by a leavening agent as reported by Peckham (1974). A leavening action may be produced by physical, chemical or biological means. Bailay (1940) has reported that double- acting and slow acting baking powders are more popular for cake baking. Unfortunately these leavening agents are chemical compounds of acids and bicarbonate, the later is considered to be carcinogenic if consumed for a long time. The wave of novel methods is geared towards elimination of such chemicals, either by using natural herbs of physical methods. In this research we considered substitution of wheat with corn flour and exploring the effect of different air incorporation methods on the quality parameters of cakes produced .The main objective of this paper is to determine the potential of replacing chemical rising of plain cakes by air pumping method, and also to check the effect of this method on composite flour of corn and wheat for cake making. This will remove the cancer fear for consuming chemically risen cakes and at the same time reduce the over dependency on wheat flour as the major ingredient in cake production.

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MATERIAL AND METHODS

Preparation

The cereal flour were procured from Umuahia main market, Abia State, Nigeria, and then screened through a laboratory sieve (Ihekoronye and Ngoddy, 1985). The wheat and corn flour were blended in the ratios of wheat to corn as 100:0; 80:20; 70:30; 30:40; 50:50 and 0:100% respectively.Two hundred grammes of each blend were mixed with the basic ingredients: 55g of sugar, 85g of margarine, 4 eggs, 20ml of liquid milk and 8g of baking powder when applicable according to method of Peckham (1974).

Air incorporation

Air was incorporated into the mixtures by either (a) Electric mixer with baking powder (b) air pumping (Piston pump) through a micro-filter, then beating (c) baking powder and beating (d) electric mixer without baking powder respectively. After

incorporating air, the batter was weighed in a balance (Metler Toledo, PL303) and baked in a gas powered oven at 175°C for 45 minutes- as adopted from Peckham (1974). The control for the experiment was 100% wheat flour cake baked without baking powder.

Determination of Physical Properties

Cake volumes were determined by the seed displacement method described by Onwuka(2005)

Cake Volume $Cm^2 = w_2 \text{ x } v_1/w_1$ (1)

Where W_1 – weight of seed that filled the container
W_2 – weight of seeds displaced by the cake sample
V_1 – Volume of container

- The specific volume was calculated according to Ayo *et al*.,(2008) as

specific cake volume = v/w (2)

Where W - weight of cake sample
V - volume of cake sample

The weight of the cake samples were obtained using an electronic weighing balance model Metler Teledo PL303 while the density was found according to Lewis(1990)

$$Density\ p = (mass)/(volume) \quad (3)$$

The baking value for the cake samples were calculate based on Ayo *et al.*, (*2008*) as

$$BV = (cake\ volume)/(100) + pore\ factor \quad (4)$$

The pore-factor (PF) was determined from pore values PV measured on a scale of 1 = very coarse-pores to 8 = very fine pores as shown below

PV	1	2	3	4	5	6	7	8
PF	30	40	50	60	70	80	90	100

Energy value was calculated using the Atwater factors of 4 x protein, 4 x carbohydrate and 9 x fat (Iwe and Ngoddy, 1998., Nwabueze, 2004)

The Proximate composition of the flour and cake samples were analyzed according to AOAC(1990) , where moisture was by furnace method, fat by soxhlet extraction, crude protein by Kjeldahl method. Total ash and carbohydrate were also determined. Sensory evaluation was carried out on the cake products by 15 trained panelist who were asked to assess the cakes for taste, texture, flavour, colour and general acceptability [Iwe,2002;Obatolu,2002)based on nine(9) point hedonic scale ranging from 1 (disliked extremely to 9 -liked extremely) for which they scored the cakes to indicate levels of like or dislike for the products .

Statistical Analysis

The data obtained from the various physiochemical and sensory analysis was subjected to analysis of variance (Anova) as described by lwe(2002). Treatment means were compared and separated using the least significant differences (LSD), and level of significances determined.

The result of the proximate composition of the flour from wheat grains (*Triticum compectium*) and corn (*Zea mays*) and the cake products, are shown in table 1 and 2 .

Table 1 Proximate Composition of Wheat and Corn Flour Blends Samples

Flour Samples WF-CF	Moisture Content (%)	Fat (%)	Protein (%)	Ash (%)	Crude (%) Fiber	Carbohydrate Content (%)
100%:0%	11.68c± .007	1.71f± 0.008	11.47a±0.0135	1.63b±0.007	2.272c±0.014	71.52c±0.272
90%:10%	11.55d±0.007	1.79d±0.0085	10.61b±0.0135	1.07f±0.007	2.45d±0.014	72.54b±0.272
80%:20%	12.33a±0.007	1.86c±0.0085	10.24c±0.0135	1.83a±0.007	2.79a±0.014	71.96c±0.272
70%:30%	10:98c±0.007	2.21b±0.0085	9.73c±0.0135	1.38d±0.007	2.56c±0.014	73.96b±0.272
60%:40%	10.76f±0.007	1.97c±0.0085	9.94c±0.0135	1.31c±0.007	2.28c±0.014	73.24b±0.272
50%:50%	10.34g±0.007	1.81c±0.0085	8.24f±0.0135	1.27c±0.007	1.94f±0.014	76.40a±0.272
0%:100%	11.93b±0.007	3.68a±0.0085	8.24f±0.0135	1.27c±0.007	2.22c±0.014	70.38c±0.272
LSD (P < 0.05)	0.041	0.05	0.08	0.043	0.08	1.60

abc means with different letters within the same column are significantly different (P≤0.05)
WF = Wheat flour
CF = Corn flour

The moisture content of the 100% wheat flour was significantly different (P ≤ 0.05) from those of corn and the corn blends, but ranged between 10.34% – 12.3%.

The 80%:20% wheat flour- corn flour blend had the highest moisture of 12.33% as shown on table 1, these values are ideal for flour storage and keeping quality since cereal flours deteriorate rapidly if moisture exceeds 14% (Ihekeronye and Ngoddy, 1985)

Table 2. Proximate Composition of Cakes from Different Flour Blends

Samples	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Crude (%)	Carbohydrate (%)
C201	11.19a±0.005	15.82c±0.01	9.15a±0.06	1.46a±0.007	1.08d±0.004	61.30c±0.09
C203	10.93b±0.005	17.83a±0.01	8.71b±0.06	1.27b±0.007	1.11c±0.004	60.15d±0.09
C205	10.88c±0.005	16.96b±0.01	8.68b±0.06	1.18b±0.007	1.15b±0.004	61.15c±0.09
C207	10.67d±0.005	15.85c±0.01	9.12a±0.06	1.43a±0.007	1.03c±0.004	61.91b±0.09
C209	9.72e ±0.005	16.04d±0.01	8.73b±0.06	1.20c±0.007	1.05c±0.004	63.26a±0.09
C211	9.67^{f}±0.005	16.22^{c}±0.01	8.70^{b}±0.06	1.15^{c}±0.007	0.97^{f}±0.004	63.29^{a}±0.09
C213	9.64^{f}±0.005	16.96^{b}±0.01	7.97^{d}±0.06	1.08^{d}±0.007	0.92^{g}±0.004	63.42^{a}±0.09
C215	10.85^{c}±0.005	17.02^{b}±0.01	8.68^{c}±0.06	1.06^{d}±0.007	1.18^{a}±0.004	61.86^{b}±0.09
(SD	0.03	0.058	0.037	0.041	0.022	0.52

^{abc} means with different letters within the same column are significantly different (P≤0.05)

C201 = cakes from 100% wheat flour (baking powder added).
C203 = cakes from 80% WF: 20% CF (baking powder added.)
C205 = cakes from 70% WF: CF (baking powder added).
C207 = cakes from 100% Wheat Flour (without baking powder).
C209 = cakes fro, 80% WF: 20% Flour (without baking powder).
C211 = cakes from 70% WF: 30% Flour (without baking powder).
C213 = cakes from 60% WF: 40% CF Flour (without powder).
C215 = cakes from 60% WF: 40% CF (without powder)

According to table 2, the moisture contents of the cakes ranged between 9.64 – 11.19%. The cake sample from 100% wheat has more water than others (11.19%) while the blend 60:40% recorded the least. Samples C211 and C213 were not significantly different in their moisture content (P≤ 0.05). The more moisture found in 100% wheat is associated with the high gluten levels which restricts the escape of water during baking(Kent ,1975)

Fat. The fat in the 100% whole wheat flour was least and significantly differed from other samples (P≤ 0.05). The higher value of fat (3.68 %) obtained from 100% corn was due to high amount of linolanic fatty acid in the grain of whole dry corn (Ekpenyong,1973) The result also showed that an increase in the level of substitution of wheat flour with corn flour consequently increased the fat content of the flour blends. The values reported here for wheat flour 100% (1.71%) and corn flour 3.68% were closer to those reported by Ekpenyong (1973) as 2.33% and 5.40% respectively.

The result of fat in table 2 shows that cake samples with 80% wf:20% cf where significantly different (P≤ 0.05) and relatively higher than other samples, but sample C201 and C207 did not differ in fat content.
The relatively high fat content in cake products is attributed to high lipid content (about 81%) in margarine used in production of cake products according to the report by Pomeranze and Melon (1994). Sample C215 or 60%:40% blends has the highest fat content. This is informed by the fact that corn contains high fat and so the higher the addition of corn, the more fat in the products.

Protein. The protein content in flour samples differed from each other (P≤ 0.05) but 100% wheat flour did not differ from 90:10% wheat – corn blend. This is true because the level of substitution is low as compared to others. Wheat flour is known to contain high protein (gluten) and is quite suitable for the production of baked foods (Kent, 1975)

The protein content of the flour blend decreased significantly with increase level of substitution of wheat flour with corn flour (table.1). This is due to low quality protein (Zein) present in corn. Okoh (1998) has reported diminished baking potential as the level of wheat substitution with corm increases. Table 2 reveals that protein content for cake sample C201 and C209 did not differ significantly. Both are produced from 100% wheat except for the different air incorporation methods. Similarly samples (203, C205, C209 and C211 did not differ in protein, but the protein content of C201 and C209 are higher than others being products of 100% wheat flour. This confirms earlier report by Okoh (1998) that various levels of substitution of wheat with corn reduces the gluten in wheat flour. Pyke (1974) observed that the protein in cake are derived mainly from egg but partly from the flour as well.

Ash: The ash in flour as shown in table 1 indicates the level of inorganic constituents (minerals) present. This result showed that 100% wheat is more in ash (1.63%) than 100% corn flour (1.52%). The ash obtained here in 100% wheat flour is similar to

(1.67%) obtained by Eke et al.,(2008) for 100% wheat. Difference exists between various blends, except between 60%: 40% and 50%:50% blends, which might have balanced in chemical composition. The ash content of the Cake products were lower compared to the flour blends and ranged between 1.06% - 1.40% as shown in table 2

Crude Fiber: The crude fiber content of the flour samples ranged between 1.94% and 2.0%, with the 50:50% wheat/corn flour blends – the lowest values and the 80:20% blend – the highest value. The values for crude fiber differed significantly ($P \leq 0.05$) among all samples, but 60:40% blend and 100% corn flour did not differ. The crude fiber in the cake samples were lower than those in the flour due to addition with other cake ingredient and ranged between 0.92% - 1.18% as shown in table ii. Fiber plays the role of bulk in diet and helps to eliminate waste from the bowl as reported by Ihekoronye and Ngoddy (1985)

Carbohydrate; Result from table 1, shows high carbohydrate for all flour samples (70.38 – 76.40%.) The 50:50% blend differed significantly ($P \leq 0.05$) from others, while the 100% wheat and 100% corn did not differ and were similar to the 71.8% obtained by Uwaezuoke (2009).The carbohydrate levels in the cake samples correlated positively with those of their flour content (61-63.42%). This shows that the cake products can serve effectively as high carbohydrate foods and consequently high energy giving food. This was shown in table 3, where the energy value ranged from 424.18J to 438.J and the cake blend of 60 : 40% had the highest value.

The major ingredients that play role in energy of material are fat, and carbohydrate, the sample has the highest carbohydrate as compared to others, consequently the highest energy value.

Effect of Air Incorporation Methods On The Physical Properties Of Cake Samples

Table 3 Effect of air incorporation Methods on the Volume, Density and Height of the Cake Samples.

Samples	Volumes $(Cm)^3$				Density g/cm^3				Height			
	A	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
M201	356	154	226	324	0.47c	1.08a	0.70c	0.51b	7.10a	3.40a	5.8a	6.72±0.071
M203	337	171	218	316	0.51c	1.01b	0.74b	0.53a	6.90b	3.30b	5.22b	6.3
M205	280	168	208	302	0.5^{7b}	1.01b	0.71c	0.54a	6.70c	3.30b	4.6b	5.84
M215	237	160	194	288	0.6^{5a}	1.06a	0.82a	0.55a	5.60a	3.0c	3.87^{c}	5.22
LSD					0.0496	0.04	0.03	0.02	0.02	0.03	0.07	0.048
SE					±0.022	0.01	0	0	0	0.04	0.01	±0.0071

abc means with different superscript within the same column are significantly different ($P \leq 0.05$)

KEY:
A Mixing with Baking Powder
B Mixing without baking powder
C Air pump method
D Addition of Baking Powder only

Table 3 shows the effect of air incorporation methods on the volume, density and height of the various cakes produced. The highest volume was obtained from those samples (A) which was mixed in electric mixer with the addition of baking powder. Baking powder has being found to have double action in cake raising, hence the best performance especially with addition of mixing. The table further revealed that the 100% wheat flour cake has the highest volume at $355.6cm^3$, notably the trend indicated that the more the substitution with corn the lesser the volume, probable this shows that the glutein which could hold the volume is reduced, hence the loss of carbon dioxide from the cakes.

Among the mixing methods, the table showed that the samples mixed without baking powder performed worst, which shows that mixing alone cannot guarantee good cake volume especially in a plain cake.

The density of the cakes was inversely proportional to the volumes as shown in table.3 The density of the cakes varied significantly across the column with 100% wheat cake having the lowest density, making

it easier for carriage as it is lighter in weight but more fragile. The density also varied between treatments, and the combination of baking powder and mixing by machine gave the less dense cakes. The structure of plain shortened cake is that of an air –in fat foam distributed in a flour-in liquid mixtures as reported by Seitz and Walker (1993). During baking, carbon dioxide combines with the air bubbles in the fat and expands through the batter, causing it to lighten, and hence a lesser dense and good quality cake. The result on table 3 further showed that the samples with lesser density expanded most in height – indication that more air was incorporated which helped in the expansion, of the cake in height. Mixing with baking powder performed best followed by air pump method.

Table 4: Effect of Air Incorporation Methods on the specific Cake Volume. Pore value, Pore Factor and Baking Values of the cake sample

Samples	Specific Cake Volume Cm^3/g				Pore Value PV				Pore Factor				Baking Value Cm^3			
	A	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
M201	2.10a	0.93a	1.42	1.98	**7**	4	4	0	90	60	60	0	320	92.4	136	0
M203	1.98b	0.99a	1.34	1.88	**6**	3	4	0	80	60	60	0	270	85.4	131	0
M205	1.75c	0.88b	1.3	1.88	6	3	3	0	80	50	50	0	224	84	104	0
M215	1.45d	0.95a	1.22	1.8	4	2	2	0	60	40	40	0	142	64	77.5	0
LSD	0.5	0.07	0.07	0.31												
SE	±0.022	0	0													

abc means with different letters within the same column are significantly different (P ≤0.65)

See table 1 for other keys.

Considering table 4, the specific cake volume, pore value, pore- factor and baking values, the samples mixed with baking powder again proved best-, followed by the air pump method. There were difference among the substitution levels in the various methods, but the 100% wheat still retained the best performing characteristic for a quality plain cake. The pore value and cake values are used to express the level of air pores and volume expansion in cakes which will affect the cake structure.

Sensory Evaluation of the Cakes Samples

The results of the Sensory properties of the cakes are not shown. The colours of the cakes did not differ except 205 which was less liked. The taste differed significantly between 100% wheat and others, but other samples did not differ among themselves. The method of air incorporation did not effect colour or test of the cakes produced. Promerenz and Melon (1994) observed that food colour often affect people's perception of sight and evaluation by other senses.

The cake colour attributes may be due to maillard reaction in which reducing sugars react with proteins, amino acids or peptides (Ihekeronye and Ngoddy, 1985). Earlier discussion has shown that 100% wheat contain more glutein protein which could be reason for higher ranking in colour attributes than others – due to intensified maillard reaction.

The texture of sample 203 was significantly different (P≤ 005) from the other samples, while the mouth feels attribute indicated difference. Generally the cakes were accepted with little preference for 100% wheat cake with addition of baking powder.

CONCLUSION

The proximate composition of the plain cakes produced showed that wheat flour can be substituted with corn flour to the level of 40%. The result of the physical properties showed that cakes produced with baking powder and mixing machine were better than others though air pump method can also be used considering the carcinogenic- properties of baking powder.

The carbohydrate and fat content of the cakes showed that they can serve as high energy foods. Organoleptically, 80%:20% blend compared favorably with 100% wheat flour cake as was shown by the rating of the panelist

The results here showed that it is possible to produce good quality plain cakes using air – pump methods without baking powder. The outcome of this research can be used to design air incorporation equipment for cake production However, this method is restricted to the use of micro air filters for hygienic purposes and this might not be within reach of small scale produces

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