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Effect of Oven Types on the Characteristics of Biscuits Made from Refrigerated and Frozen Doughs

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Summary

Characteristics of sugar snap and chocolate chip cookies, and hazelnut biscuits made from refrigerated and frozen dough were studied. Doughs were stored at 4 °C for 6 weeks and at –18 °C for 6 months, respectively. Physical characteristics of the biscuit samples such as spread, baking loss, surface colour and density were determined. Dough colour was not affected by storage time and temperatures. Biscuit characteristics did not change significantly during storage. Spread ratio was significantly lower for the biscuits baked in the gas oven than for the biscuits baked in the electric oven. Biscuit dough can be refrigerated for 6 weeks, and frozen for 6 months. Results also suggest that unique quality differences exist between the two ovens. For sugar snap cookies and hazelnut biscuits the electric oven without air circulation was better, while for chocolate chip cookies gas oven with air circulation was more suitable.

Key words: biscuit, refrigerated dough, frozen dough, oven type

Introduction

Most biscuits and cookies are chemically leavened baked products. They are stable foods and have advantages such as long shelf life and good eating quality. The physical properties of the doughs and the recipes in biscuit making depend on the type of biscuits and the method used in the dough formation (*1*). Quality standards from the raw materials to the end product are essential in biscuit making.

Bakery products are one of the most profitable segments in supermarket retailing. The use of frozen dough by retail bakers has advantages and is more convenient compared to the traditional baking from scratch. In supermarket bakeries, the baker prefers refrigerated and frozen dough because of the cost of skilled bakers, restricted time and equipment. Refrigerated and frozen dough technology allows the baker to bake a variety of products, without holding many ingredients in stock, and without having to scale and mix ingredients for several types of dough. Considering all expenses, the final cost of frozen dough to the baker is lower than starting from scratch (*2*).

An important requirement for refrigerated and frozen products is to keep functional properties at the level of freshly mixed dough (*3*). In frozen dough technology, the quality of the dough should be high and changes that may occur during the storage period should be at minimum level. Inadequate refrigeration during transportation, improper handling and storage in the bakery cause temperature fluctuation that reduces frozen dough quality, especially in yeast leavened dough. These factors may also affect the quality of chemically leavened dough even though biscuit dough is lower in moisture, chemically leavened and generally higher in fat and sugar.

The recipe and mixing of the chemically leavened dough is the same as for fresh dough for immediate baking. The packaging design of the product before freezing is important because biscuit dough is best

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frozen in the shape of cylinders. A minimum amount of thawing time before baking is important (2). Antioxidants and antimicrobial agents can be added to the dough to increase shelf life of the product.

Chemically leavened frozen dough must be thawed before baking. The time required for thawing the dough affects the final product quality. Dough should be thawed for 16 hours in a retarder or a refrigerator. Biscuit dough may be thawed and held in the refrigerator for several days since these doughs are stable at 5 °C. Chemically leavened doughs need slightly longer baking time if they are kept in a refrigerator or a retarder just before baking (2).

Food companies have been working to offer easy-to--prepare and ready-to-eat foods to meet the demands of working households. In-store bakeries have played a major role in profit contribution to supermarkets and their numbers have increased in recent years. Among refrigerated and frozen doughs, danish-type doughs, frozen pizza, yufka (thin parbaked dough layer), baklava dough, manti (meat-filled small dough) are popular items in supermarkets. In general, chemically leavened doughs are not common as yeast leavened ones. Biscuit, *i.e.* cookie, dough is not found in Turkey as may be seen in Western countries. Customers demand a variety of tastes at increasing levels. It is difficult to offer many items from in-store bakery with many constrains as indicated above.

Customer can either buy freshly baked biscuits or bake them at home. Quality fluctuation is a detrimental factor for the customer. They demand the same taste that they are familiar with. Making the dough with careful preparation in the central warehouse and transporting it to the stores is the best way to fulfill this request.

Biscuit quality and baking time also change with oven design and operating parameters. These parameters must be well established and controlled for each type of baked products. In the production of biscuit dough, dough-mixing procedure, packaging of the product before freezing, storage period for refrigeration and freezing should be well established for high quality product. In this study, quality differences of biscuits made from fresh, refrigerated and frozen dough were compared. The effects of storage time and oven types were investigated.

Materials and Methods

Materials

Commercial biscuit flour with 10.3 % protein and 0.53 % ash (14 % mb) were used in the study. A commercial hydrogenated vegetable shortening, NBY from Besler Food, Inc. (Istanbul), wheat starch from Kenton Gida, Inc. (Istanbul), dextrose, $NaHCO_3$ from Ustalar Food, Inc. (Istanbul) were provided. Fine pure beet sugar and chocolate drops were obtained from the market. SFI index of the shortening was 31.4, 11.4 and 6.8 for 20, 30 and 35 °C, respectively.

Biscuit recipes

In the study, doughs for sugar snap cookies, chocolate chip cookies and hazelnut biscuits were prepared with the following ingredients (Table 1). For mixing the dough samples, KitchenAid KSM45 mixer (KitchenAid Europa, Inc., Brussels, Belgium) in the preliminary stage, and a dough mixer with a flat beater (OM20, Oztiryakiler, Inc. Istanbul) in the main experiment were used.

Table 1. Ingredients for biscuit recipes

m(ingredients)/g	Sugar snap	Chocolate chip	Hazelnut
Flour	100.0	100.0	100.0
Sugar	60.0	80.0	80.0
Chocolate chip	–	60.0	–
Hazelnut	–		60.0
Shortening	30.0	50.0	50.0
Egg	–	30.0	30.0
Water	21.0	–	–
Starch	10.0	–	–
Sodium bicarbonate	1.1	1.5	1.5
Dextrose	1.0	–	–
Vanillin	–	1.5	1.5
Salt	1.0	1.0	1.0
Potassium sorbate	0.3	0.3	0.3

Preparation of biscuit doughs

Sugar snap cookies

Sugar, salt, sodium bicarbonate and shortening were creamed with a flat beater for 2 min at 90 rpm, scraped and mixed for 1 min at 130 rpm. After measuring specific gravity, water containing dextrose and potassium sorbate was added to the cream and mixed for 1 min at 60 rpm, scraped and mixed for another 1 min at 90 rpm. Finally, sifted flour was added and mixed for 1 min at 60 rpm, scraping twice to obtain homogeneous dough. Total mixing time was 6 min.

Chocolate chip cookies and hazelnut biscuits

Sugar, salt and shortening were creamed with a flat beater for 3.5 min at 90 rpm, scraping after 30 s. Eggs, vanillin and potassium sorbate were added and mixed for 2 min at 90 rpm. Sifted flour containing sodium bicarbonate and chocolate chips or hazelnuts, depending on the recipes, were added and mixed for 15 s at 60 rpm, scraped and mixed for additional 15 s at 90 rpm. Total mixing time was 6 min, as for sugar snap biscuits.

Dough freezing and storage

Biscuit dough samples obtained at 22 °C were filled into a synthetic polyethylene case, 40 mm in diameter (Aksun Food, Istanbul) and the ends were closed with plastic clips (Fig. 1). Each dough pack was coded, and stored for 6 weeks at 4 °C and for 6 months at –18 °C.

Fig. 1. A sample of biscuit dough filled into a case

Preparation and baking of biscuits

The dough samples kept at 4 °C and at –18 °C were baked and analysed in weekly and monthly intervals, respectively. Dough samples were taken from the refrigerator or freezer and kept until the temperature in the centre reached 22 °C. Sugar snap cookie dough samples were sheeted and shaped according to the AACC Method 10.52 (*4*). The other two biscuit dough samples were shaped using an ice cream dispenser, 35 mm in diameter (Sancar Food, Istanbul). Optimum baking temperatures for each type of oven were determined in the preliminary study. The biscuits were baked at 175 °C for 12 min in the gas oven with air circulation (Pastamatik-PS5, Koseoglu, Istanbul) and at 205 °C for 13 min in the electric oven without air circulation (Bosch, Istanbul). The biscuits were cooled to room temperature and then weighed.

Evaluation of dough and biscuit samples

Specific gravity of sugar snap cookie dough was determined as described by Dogan and Walker (*5*). Diameter (W) and thickness (T) of six biscuits of three types were measured by placing them edge to edge and by stacking one above the other in height (H). Measurement was repeated twice by rearranging and restacking. Spread factor (W/H·100) was calculated. Moisture loss was estimated by weighing the dough and the biscuits. Biscuit densities were calculated and expressed as g/cm^3 for three types of biscuits. Evaluation of the samples was performed weekly or monthly depending on the storage temperature.

The dough and biscuit colours were determined as described by Dogan (*6*). L values (lightness scale: black 0, white 100) were compared for each tested combination. The dough for hazelnut biscuits and chocolate chip cookies had the same ingredients except for hazelnuts and chocolate. Therefore, dough colour measurement was only performed on sugar snap cookies and hazelnut biscuit dough samples. For surface cracks, biscuit samples were scanned using a flatbed scanner; and pictures were saved. At the end of experiment, the pictures and biscuit samples were visually compared with each other for cracking patterns.

Data analyses

The experiment was planned according to the randomised block design with two replicates. The effect of storage time and oven type on dough and physical properties of each type of biscuits made from refrigerated and frozen dough were evaluated and compared with control dough, and least significance differences (LSD) were computed at $p<0.05$ if difference exists using the Solo Statistical Software 6.0.4 (BMDP, Saugus, MA, USA).

Results and Discussion

Dough properties

The average lightness (L) values of control dough for sugar snap cookies and hazelnut biscuits before refrigeration and freezing were 84.3 and 72.9, respectively. In the study, the density of the control dough for sugar snap cookies was recorded as 1.46 g/cm^3. During storage at both storage temperatures, the density did not alter significantly ($p>0.05$). At the end of six weeks of storage the dough colour of two types of biscuits did not change significantly ($p>0.05$). L value changed between 84 and 85 for sugar snap biscuit dough and between 67 and 73 for hazelnut biscuit dough.

During six months of storage the colour of two types of biscuits did not change significantly ($p>0.05$) either. The L values of samples were 84–86 for sugar snap cookies and 68–76.5 for hazelnut biscuit dough during six months of storage. Dough colour of sugar snap cookies was lighter than the colour of the chocolate chip cookies and hazelnut biscuits because of the variations of ingredients.

Biscuit properties

Surface colour and properties

The average L values of control biscuits baked in gas oven for sugar snap cookies, hazelnut biscuits and chocolate chip cookies before refrigeration or freezing were 81, 71 and 73, respectively. The L values of those baked in electrical oven were 84 and 73, respectively. The dough colour of biscuits did not change significantly during six weeks of storage ($p>0.05$). The L values ranged from 75 to 83 for sugar snap cookies, from 69 to 72 for hazelnut biscuits, and from 64 to 73 for chocolate chip cookies.

On the other hand, storage time and the type of oven affected the surface colour of sugar snap cookies made from frozen dough. The L values ranged from 77 to 82 for sugar snap cookies, from 65 to 73 for chocolate chip cookies, and from 69 to 72 for hazelnut biscuits during frozen storage. Variations of ingredients among the tested biscuits also contributed to the colour difference. The L values slightly decreased for all three types of biscuits with increased storage time, indicated by darker surface colour with time. This difference was only significant for sugar snap cookies ($p<0.05$). The mean colour of biscuits (refrigerated and frozen) baked in a gas oven was darker (L=78) than that of biscuits baked in an electric oven (L=80).

The surface colour of sugar snap cookies was significantly affected by the type of oven ($p<0.05$). The colour of sugar snap cookies baked in the gas oven had lower L values (darker) than the colour of those baked in the electric oven. The type of oven did not affect the surface colours of chocolate chip cookies and hazelnut biscuits. Biscuit surface colour is the most important indicator of the degree of baking as a function of baking time, temperature and air circulation, and should be strictly controlled.

Surface cracking is another critical factor, especially for sugar snap cookies. The cracking pattern did not significantly change with storage time for all three types of biscuits. However, the type of oven affected the cracking pattern and the depth of cracks, especially on sugar snap cookies (Fig. 2). Surface cracks were larger and deeper on the biscuits baked in the electric oven than in the gas oven. Air circulation in the oven is a controlling factor for surface cracking. The air circulation in the gas oven caused the cookie surface to dry quickly, thus reducing cracking.

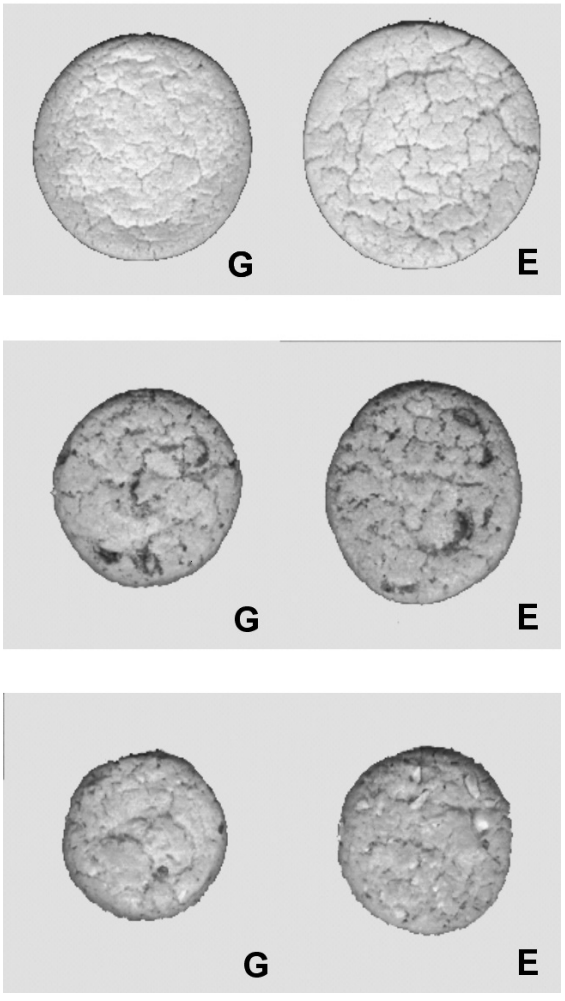

Fig. 2. Effects of the gas (G) and electric (E) ovens on the surface appearance of control biscuits

Baking loss

Baking losses of control biscuits made from three different combinations of ingredients are given in Table 2. The baking loss during refrigeration varied from 12.4–14.3 % for sugar snap cookies, from 10.5–12.7 % for chocolate chip cookies, and from 10.3–11.3 % for hazelnut biscuits. Baking loss did not significantly change with storage time for all three types of biscuits ($p>0.05$).

Table 2. Effects of oven type on mean baking loss (%) of control biscuits made from freshly mixed dough

Type of oven	Type of biscuits		
	Sugar snap	Chocolate chip	Hazelnut
Gas	14.5	11.0	11.3
Electric	12.2	10.2	10.6

The baking loss was 12.9–13.8 % for sugar snap cookies, 10.3–12.7 % for chocolate chip cookies, and 10.1–11.3 % for hazelnut biscuits made from frozen doughs. The baking loss was 1–2 % higher in the gas oven for all three types of biscuits, as a result of air circulation that caused increased moisture removal rate. The highest loss in sugar snap cookies was probably a result of higher initial moisture content of the dough. Dogan and Walker (*5*) showed similar result, where baking loss increased by 2.1–2.6 %, depending on the baking time and fan speed.

Biscuit spread ratio

Effect of oven type on mean spread ratio of control and experimental biscuits is shown in Tables 3 and 4. The storage time in the freezer was not a critical factor affecting biscuit spreading. As shown in Fig. 2, spread ratio of chocolate chip cookies was higher than of hazelnut biscuits because of the fat content of chocolate chips in the recipe. Spreading during baking also affected the surface characteristics. A higher spread of chocolate chip cookies made the surface smooth. On the other hand, the surface of hazelnut biscuits wrinkled as a result of low spreading during baking.

Table 3. Effects of oven type on mean spread ratio (W/H·100) of control biscuits made from freshly mixed dough

Type of oven	Type of biscuits		
	Sugar snap	Chocolate chip	Hazelnut
Gas	77.4	60.3	41.8
Electric	84.7	74.9	49.9

Table 4. Effects of oven type on mean spread ratio (W/H·100) of biscuits made from refrigerated (R) and frozen (F) dough

Type of oven	Type of biscuits					
	Sugar snap		Chocolate chip		Hazelnut	
	R	F	R	F	R	F
Gas	73.8^a	74.6^a	56.7^a	58.6^a	38.5^a	37.5^a
Electric	80.9^b	81.8^b	75.3^b	73.3^b	48.0^b	47.7^b

Values for a particular column followed by different letters differ significantly ($p<0.05$)

Oven type influenced the spread ratio of sugar snap and chocolate chip cookies. As indicated by Dogan and Walker (*5*), faster heat transfer and higher moisture removal rate significantly lowered the spread ratio and altered the biscuit texture. Consistency of biscuit size is of major importance in packaging, considering that cookie packages have standard net mass, labels and sizes. If the biscuits have excessive spread, they will break when being placed in the box. If the spread is insufficient, then the box will not be completely filled and the net mass may vary. Therefore, every batch must be uniform (*7*).

Flour quality refers to the ability of flour to produce good quality products under specifications set by the customers. Size of biscuits (spread ratio) is one of two main factors in achieving a good quality product. It is an indication of the viscous property of the dough and is influenced by the recipe, ingredients, procedures and conditions used in biscuit production (*8*).

Density of biscuits

The densities of control biscuits are given in Table 5. Mean densities of biscuits made from refrigerated dough were 0.52, 0.38 and 0.40 for sugar snap, chocolate chip cookies and hazelnut biscuits during the study, respectively. Mean biscuit densities made from frozen dough were 0.49, 0.38 and 0.39 for sugar snap, chocolate chip cookies, and hazelnut biscuits, respectively. Density was the best index of sensory texture of biscuits. Lower density means greater crispiness and higher textural value. Manohar and Rao (*9*) found a positive correlation between dough firmness and density and a negative correlation between dough stickiness and density of rotary moulded biscuits. Biscuit density is a physical property, it is easy to calculate and it is an objective measurement.

Table 5. Effects of oven type on mean densities (g/cm^3) of control biscuits made from freshly mixed dough

Type of oven	Type of biscuits		
	Sugar snap	Chocolate chip	Hazelnut
Gas	0.49	0.40	0.39
Electric	0.52	0.39	0.36

Sugar snap cookies had higher density than the other biscuits because of lower shortening content and existence of water in the recipe, which caused gluten development to certain extent. Therefore, sugar snap cookies were least crispy; hazelnut biscuits and chocolate chip cookies followed. There was no significant difference between the biscuits made from refrigerated and frozen dough in terms of density ($p>0.05$).

Oven type had also no effect on the density of sugar snap and chocolate chip cookies. However, densities of experimental hazelnut biscuits baked in the gas and electric oven were 0.40 and 0.37, respectively and they differed significantly ($p<0.05$).

Conclusions

The colours of refrigerated and frozen doughs during storage did not differ from the freshly mixed dough. Dough quality did not deteriorate during 6 weeks of refrigeration and 6 months of freezing. The surface colour of the sugar snap cookies was affected by the oven type, while that of chocolate chip cookies and hazelnut biscuits was not. Among the physical properties, baking loss, spread ratio, surface characteristics and biscuit density did not change with storage time and temperatures. Biscuit dough can be stored at 4 °C for 6 weeks, and at –18 °C for 6 months. Unique quality differences exist between the two ovens; the spread ratio was significantly lower for the biscuits baked in the gas oven than that for the biscuits baked in the electric oven. It was concluded that electric oven without air circulation was better for baking sugar snap cookies and hazelnut biscuits, and the gas oven with air circulation was better for chocolate chip cookies.

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Utjecaj tipova peći na svojstva keksa pripravljenih od rashlađenog i zamrznutog tijesta

Sažetak

Ispitana su svojstva prhkih kolačića sa šećerom, sa čokoladnim listićima i keksa s lješnjacima, pripravljenih od rashlađenog i zamrznutog tijesta. Tijesto je bilo pohranjeno 6 tjedana pri 4 °C, te 6 mjeseci zamrznuto na –18 °C. Određene su fizikalne osobine uzoraka keksa, kao što su površina, gubitak pri pečenju, boja površine i gustoća. Vrijeme skladištenja i temperatura nisu utjecali na boju tijesta kao ni na svojstva kolačića. Keksi pečeni

u plinskoj peći imali su manju površinu od onih pečenih u električnoj. Tijesto se keksa može držati u hladnjaku 6 tjedana ili zamrznuti 6 mjeseci. Rezultati pokazuju da postoje razlike između dviju vrsta peći. Električna peć bila je bolja za pripravu prhkih kolačića sa šećerom i keksa s lješnjacima, dok su se kolačići sa čokoladnim listićima bolje ispekli u plinskoj peći sa cirkulirajućim zrakom.