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Investigating the Qualitative Characteristics of Toast Bread Obtained from Par-Baked Paste Kept in the Fridge and the Freezing Condition over Zero Degree

***Zohreh Feiz Abadi[1], Mania Salehi Far[2], Mohammad Reza Ishaghi[3]**

[*1]M.Sc Student of Department of Food Science and Technology, Varamin – Pishva Branch, ***Islamic Azad*** University, Varamin, Iran
[2]Assistant Professor Department of Food Science and Technology, Shahr-e-Ghods Branch, ***Islamic Azad*** University, Tehran, Iran
[3]Assistant professor of Department of Food Science and Technology, Varamin – Pishva Branch, ***Islamic Azad*** University, Varamin, Iran

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ABSTRACT

Producing par-baked bread is one of the new methods to increase the shelf life of bread, thus reducing waste which has the possibility of industrial production. In the present study, the data was collected through conducting experiments which included 3 stages of keeping bread in the freezer above zero, below zero degrees and the room temperature, respectively. First, the samples were kept in -18 °C temperature for 20 and 30 days, the temperature of 1 °C for 15 and 20 days and 4 ° C for 10 and 15 days in the freezer and after spending the desired storage time, flour experiments (moisture, pH, ash and gluten), investigating bread microstructure by scanning electron microscopy, physical and chemical characteristics and sensory tests of baked breads were conducted. Using the SPSS software 18, the data was statistically analyzed. The results indicated that the treatment stored at -18 °C for 30 days (frozen paste) had the most hardness of tissue along with the treatment at -18 °C for 20 days, also the highest staling, lowest volume, high moisture, the lowest cavity in the tissue, the highest external sensory scores of bread and has the highest score of chewing, taste and tissue. In treatments, the highest total sensory score and the minimum level of staling was in the control group and the highest internal sense scores was related to the -18 °C for 20 days (frozen paste). The maximum cavity and the most specific volume was related to the control group. In general, it was concluded that the best treatment, is the treatment kept at 4 °C for 10 days in comparison to the other treatments after the control group with regard to the specific volume, cavity, staling and the structure of the tissue.

KEYWORDS: staling, par-baked bread, frozen paste

INTRODUCTION

Wheat and its products, especially bread is the main food source for many countries in the world and provides much of daily energy, protein and minerals needed by many people. Bread is one of the oldest food products and improving its quality and reducing its wastes have always been attended by many researchers (Bhattacharya et al, 2003, Hegazy et al, 2009).

In general, in order to reduce bread waste we refer into two categories. One is to detect and eliminate the bread imperfections and the other is to increase the quality of baking bread. Bread imperfections include lesions caused by wheat quality, consumed flours, improper processing of paste, baking conditions, lack of using ameliorating materials and also lack of correcting bread storage by the consumer, preparation type of the paste and keeping it. In order to improve the quality of baking bread we can also refer to the oven temperature regulation and the production of par-baked bread (Fakhrai, 1993).

In contrast to other types of bread, industrial breads have very little wastes and due to the high baking quality, wide product variety, good shelf life and complete conduction of paste fermentation has a perfect place. From among the most important types of industrial bread, we can refer to toast bread which is one of the most consumed breads in the world, especially in Europe and US (Mohamed et al, 2010; Aparicio et al., 2007).

Producing par-baked bread is one of the new techniques that has been introduced to increase shelf life and therefore decrease bread waste since 1990 and has the capability to be produced industrially. Par-baked bread paste is prepared somewhat like the regular bread paste. Then the bread is baked in the oven until the formation

Corresponding Author:** Zohreh Feiz Abadi, M.Sc Student of Department of Food Science and Technology, Varamin – Pishva Branch, ***Islamic Azad University, Varamin, Iran

of the inner part of the bread without the crust color and flavor. That is why it is cald par-baked bread. After being packed, the product can be kept in room temperature or can be frozen (Hamdami et al, 2007).

One of the major benefits of par-baked bread is that the final process of baking bread in the oven that is the color and flavor formation stage takes place in the consumption site. So, it has more marketability and satisfaction than regular bread. The reason of constant quality of par-baked bread, is complete baking of the bread after the storage period which compensates most of the undesirable features which have been resulted in staled bread (Hegazy et al, 2009).

To produce a bread with a proper quality in this method, we need to prepare special conditions at maintenance and final baking. Maintaining at room temperature, keeping at low temperature, freeze storage, storage in modified atmosphere are among the maintenance methods of par-baked breads. Keeping at room temperature even if the par-baked bread is properly packed, has still short shelf life at room temperature. Over time, the incidence of mold on the bread, and change in the bread moisture will finally cause the loss of fresh taste in most parts of the bread (Barcenas and Rosell, 2007).

Storing par-baked bread at low temperature causes slower development of undesirable taste and mold growth due to less moisture released from the inside of the bread to its crust in comparison to the storage at room temperature (Barcenas and Rosell, 2007).

During freezing storage, the bread produced has a wetter inside, crispy crust, fresh bread taste in comparison to the bread stored at room temperature. Producing frozen paste improves the quality and increases the shelf life up to several weeks, and causes the distribution of the product to distant places (Dehgan Tanha et al., 2012). Organizing the activities of bakeries is to reduce or totally eliminate the night shift (Angiolani et al, 2008).The use of frozen paste, provides the production possibility, distribution and storage of frozen pastein the industrial scale (Phimolsiripol et al, 2008).

However, this method has damaging effects on the structure of the paste and yeast cells. Electron microscopic studies, demonstrated the failure in the gluten network during freezing or defreezing which is the result of the formation of large crystals and reduced power of maintaining gas and the volume of produced bread (Jinhee and William, 2009).

Carbon dioxide production decreased by freezing. This led to increased leavening time of the paste, reduced bread volume and increased hardness of the bread inside (Aibara et al, 2001).

Three modified atmosphere storage method increases the shelf life of bread, especially regarding microbe. Carbon dioxide causes slow growth of yeasts and bacteria and prevents the growth of molds. During prolonged storage of par-baked bread under modified atmosphere conditions, the high distribution of moisture from the inside to the crust is done, the result of which is the increase in the final cooking time and causes the bread moisture not to be stabilized desirably inside it (Barcenas and Rosell, 2007).

In general, most conducted studies are about the sustainability of these types of bread in freezing conditions, but as the freezing process is costly and has devastating effects on the paste and its quality, therefore, in this research we try to compare the storage method in a temperature above zero and investigate the effect of each on paste and bread properties.

MATERIALS AND METHODS

Raw materials needed for cooking toast, included null wheat flour (Galikash factory), salt (Taraneh factory), yeast (Golmayeh Company), sugar (Varaminsugar factory) margarine (Mahgol factory) and the needed water was prepared from the piped water of the factory equipped with a filtration system (hardness of the water was about 100-150ppm with 30˚ c.

It should be noted that in all the tests, the control group with code C, treatment of the bread resulted from a par-baked paste stored at -18°C for 30 days was coded as S_{31}, the treatment stored at-18°C for 20 days was coded as S_{32}, the treatment stored at 1°C for 20 days was coded as S_{22}, the treatment stored at 1°C for 15 days was coded asS_{21}, the treatment stored at 4°C for 15 days was coded as S_{12}, the treatment stored at 4°C for 10 days was coded as S_{11}.

Chemical experiments of flour:

Chemical analysis carried out on wheat, include:

Measuring the moisture content of the flour conducted through AACC method No. 44-A16, measuring the pH of flour through AACC Method No. 52-02, measuring the flour ash through AACC method No. 08-01, measuring the flour protein through AACC method No. 46-12, measuring flour gluten through AACC method No. 38-11 and the acidity of flour was also performed according to National Standard of Iran in No. 103.

Physical experiments of bread:

Hardness of the bread tissue (1999), in number AACC74-09, bread staling (Behzad Nasehi et al., 2009), moisture of the whole bread and its inside (Shittu et al, 2008), the ratio of inner weight to crust weight (Rosell & Satos, 2010), were investigating the microstructure of bread through electron microscopy scanning in the standard number 14095.

Methods to produce toast breads and how to bake them

In order to produce toast, the raw material (null wheat flour, water, salt, Saccharomyces cerevisiae yeast and margarine were prepared and distributed. Combination percentages were respectively as flour (59%), water (29.6%), sugar (6%), margarine (2.4%), yeast (1.8%), and salt (1.2%). First, the powder materials are poured into the mixer and were mixed well and then water and at the end yeast and margarine were added to the above mixture. So in the end, a quite homogeneous paste was obtained.

In the next step, the paste was divided into 400 gr pieces after the primary resting period, then the chins were rolled and the rolls were placed into the dish and transferred to the oven, stove temperature and humidity were respectively as 38°C and 80%, and the fermentation time was 80 minutes. After the secondary fermentation stage, the molds were transferred to an oven with a temperature of180°Cfor 70 minutes. After being par-baked and getting out of the oven and emptying the molds, the samples were cooled in room temperature. Then they were packed in epoxy polypropylene bags and were coded. After passing the storage period in the specified conditions they were placed again in the oven with 190°C for 30 minutes was taken out from the oven and were cooled in room temperature and then were packed in polypropylene epoxy bags and were coded. Therefore, they were stored in 7 different storage conditions and time and three samples were taken for 3 replications of experiments from each of them.

Evaluating organoleptic characteristics of bread through sensory method

In order to evaluate the organoleptic characteristics through sensory method, such as (volume, crust color, crust features, fractures and cuts, shape appropriateness, tissue, aroma, taste, chewing and containing holes) in toast breads of control and treatment groups together, analyzing their characteristics were used based on the five senses. The criteria were the personal ideas of the trained people towards the breads. In this study, the samples were coded and evaluated by 10 trained raters (Payan, 2012).

Statistical analysis method

In order to analyze the data, a completely randomized design with three replications was used and the comparison of means was done through Duncan's multiple range test and were analyzed using SPSS software version 18.

DISCUSSION

According to the analysis results of the consumed flour in Table 1 the amount of protein is12.5% and our proper methods to bake bread are the par-baked and frozen methods. It is better to use strong flour in the process of solidification because according to scientists at the sensory evaluation, the type of flour and the freezing method has a significant effect on the form of bread and the upper bread crust. Also type of the flour has a significant relationship with the characteristics of the lower crust surface, chewiness and smell and the taste of bread (Koushkiet al., 2010, Wolt and Dappolonia 1984).

As is clear from Table 2 the results from the analysis of variance for crust weight to the weight of the bread inside for different treatments of experimental on different days indicate no significant effect of treatment on the above feature. The lower this ratio, it is indicative of the lower crust or in other words its thinness, because the thickness of the crust is an undesirable feature in toast and the transfer of moisture from the inside to the crust increases, its staling also improves and the quality reduces.

In table 3 of the results, a significant difference was observed between the treatments ($P < 0/05$). Bread hardness during storage, is usually attributed to drying the inside of the bread but the mechanism of these changes go beyond a simple moisture transfer from the inside to the crust. The hardening process of the tissue is mainly due to two reasons; hardness resulting from the transfer of moisture from the inside to the crust and hardness which goes back to the crystallization of starch. (Guy et al., 1983)

Due to freezing because of the damaging effect of ice crystals, components such as starch and protein that has the ability to hold water (which cause the maintenance of the tissue and the softness of bread during storage) results to destruction and no longer able to keep water and therefore the extraction of water from inside the bread, has caused bread hardness, so that the hardest bread during the storage of maintained breads have been in freezing conditions which allows amylose to leave granular structure. Consequently, inside the bread becomes hard. Another reason for the hardness of the bread inside is the growth of ice crystals during the freezing storage which can damage the denatured protein matrix formed by proteins (Barcenas and Rosell, 2006).

Table 1 - Characteristics of wheat flour used in the production of toast bread

Treatment	(%)moisture	(%)total ash	(%)Acid-insoluble ash	(%) protein	(%)acidity	(%)PH
Null wheat flour	12.5	1.1	0.03	12.5	2.2	5.7

Table 2. The mean comparison of treatments on different days for the crust weight ratio to the crumb weight

Treatment	Day		
	1	3	5
(control) C	^{a}0.53A	^{a}0.52A	^{a}0.61A
(30 days -18°c)S_{31}	^{a}0.83A	^{a}0.62A	^{a}0.79A
(20 days-18°c)S_{32}	^{a}0.79A	^{a}0.63A	^{a}0.72A
(20 days1°c)S_{22}	^{a}1.05A	^{a}0.70A	^{a}0.69A
(15 days1°c)S_{21}	^{a}0.83A	^{a}0.66A	^{a}0.75A
(15 days4° c)S_{12}	^{a}0.77A	^{a}0.73A	^{a}0.82A
(10 days4° c)S_{11}	^{a}0.86A	^{a}0.78A	^{a}0.69A

* Same small letters indicate no significance in the column. * Same capital letters indicate no significance in the row.

Table 3. Comparison of treatment means for the total hardness of bread on different days.

Treatment	Day		
	1	**3**	**5**
(control) C	^{a}5.01 A	^{a} 6.12 AB	^{bc} 7.00 B
(30 days -18°c)S_{31}	^{ab}4.80 C	^{a} 6.30 B	^{a} 8.78 A
(20 days-18°c)S_{32}	^{ab} 4.80 C	^{a} 6.39 B	^{a} 8.59 A
(20 days1°c)S_{22}	^{bc} 4.33 B	^{ab} 6.10 A	^{ab} 7.88 A
(15 days1°c)S_{21}	^{bc} 4.30 A	^{ab} 6.09 AB	^{ab} 7.74 A
(15 days4° c)S_{12}	^{bc} 4.30 A	^{ab} 5.33 A	^{cd} 5.73 A
(10 days4° c)S_{11}	^{c} 3.79 B	^{b} 4.72 AB	^{d} 4.94 A

* Same small letters indicate no significance in the column. * Same capital letters indicate no significance in the row.

Table 4. Comparison of the staling of the treatments

Treatment	Satlity
(control) C	1.966
(30 days -18°c)S_{31}	3.98
(20 days-18°c)S_{32}	3.79
(20 days1°c)S_{22}	3.58
(15 days1°c)S_{21}	3.41
(15 days4° c)S_{12}	1.43
(10 days4° c)S_{11}	1.15

As is clear from the numbers in the table, by the increase in cold temperature and freezing and near freezing the staling level increases, in other words, the hardness of the bread inside increase via freezing storage of the bread.

Hardness of the bread inside is a signs of bread staling which mainly occurs through retro gradation of starch, forming crosslinks between gluten and starch chains and the transfer of water to the surface of the crust (Barcenas and Rosell, 2006, Berglund et al, 1993, Karaoglu and Kotancilar, 2006).

Table 5. Mean comparison of treatments for specific volume

Treatment	Specific volume
(control) C	^{a}4.46
(30 days -18°c)S_{31}	^{c}3.38
(20 days-18°c)S_{32}	^{c}3.35
(20 days1°c)S_{22}	^{bc}3.70
(15 days1°c)S_{21}	^{abc}3.91
(15 days4° c)S_{12}	^{ab}4.21
(10 days4° c)S_{11}	^{a}4.44

* Same small letters indicate no significance in the column.

There is a significant difference between the treatments (P <0.05). It can be said that due the damaging effect of the crystals, the structure of the paste is destroyed and weakened and the weak paste is not able to hold the gas bubbles and as a result the special volume of the frozen treatments have decreased. On the other hand, by the destruction of the bread construct, it is not able to hold water and due to the destruction of the paste network, the extraction of water has been done fast and staling increases and less volume is expected from bread. It was indicated that through increasing the freezing temperature the volume of the loaf reduces (Jinhee and William, 2009).

Table 7.The comparison of the treatments' mean for moisture

Treatment	Moisture
(control) C	^{b} 27.79
(30 days -18°c)S_{31}	^{a} 29.09
(20 days-18°c)S_{32}	^{b} 26.19
(20 days1°c)S_{22}	^{d} 21.13
(15 days1°c)S_{21}	^{d} 20.50
($^{(}$15 days4° c)S_{12}	^{a} 24.43
(10 days4° c)S_{11}	^{a} 24.49

* Same small letters indicate no significance in the column.

There is a significant differences between the treatments regarding the bread moisture (P <0.05). As it is indicated in the results par-baked bread stored in -18 °C has higher moisture than par-baked bread stored at positive (above zero) temperatures and it is possible that due to the difference in the final cooking time or due to condensation of water resulted from ice crystals that have been existed in the product and has caused increase in moisture content. It seems that the hardness of the bread inside due to moisture transfer from the gluten to starch (Barcenas and Rosell, 2006 and Willhoft, 1973).

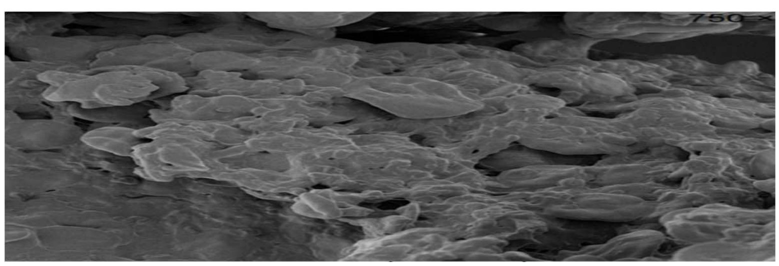
The amount of freezing water during freeze storage of paste and par-baked bread increases, which can cause the return of ice crystals. Since the gluten network is denatured, in par-baked bread before freezing, the main reason for the increase of freezing water in this type of bread is due to the freezing of the redistribution of cold water in the redistribution of water in the system (Barcenas et al., 2003 and Ribotta et al., 2003).

The control sample.

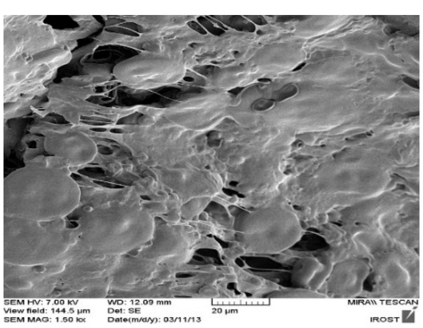
It can be said that the temperature and duration of storage is an important factor in bread features such as the number of cavities, bread volume, gluten and starch matrix fibril arrangement together as well as theirsize are conformity to reports (Yi et al, 2008).

On the other hand, deformation of bread from freezing and the growth (increase) of ice crystals during freezing storage can damage the protein network and starch granules and cause large gluten fibrils and starch polymers which are consistent with (Barcenas and Rosell, 2006).

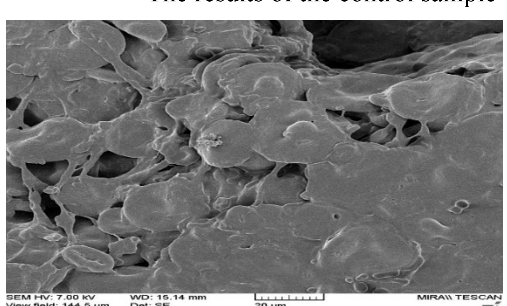
The electron microscope Scanning comparison to typical treatments Witness



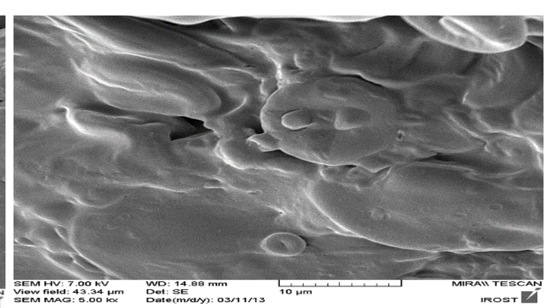
The results of the control sample



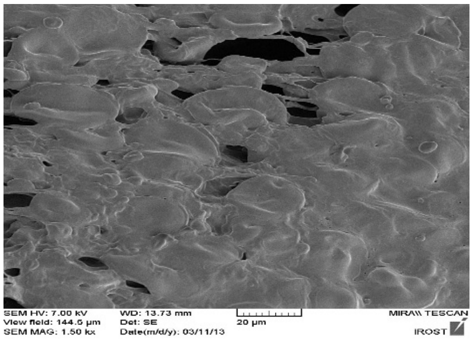
(4°C) for 10 days



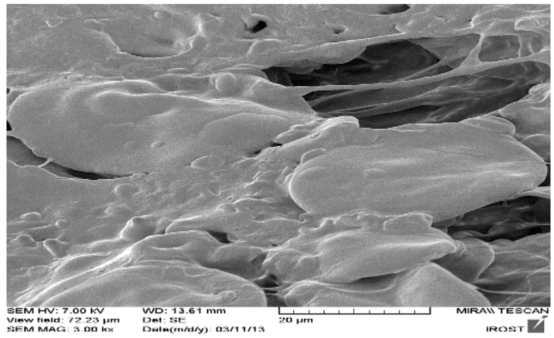
(4°C) for 15 days



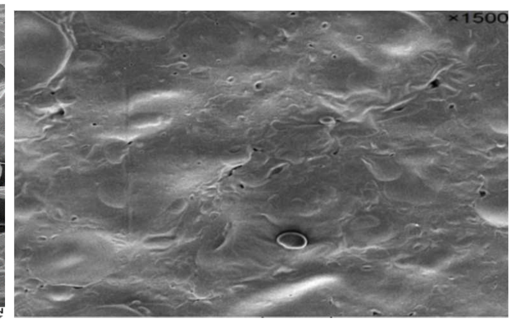
(-18°C) for 20 days



(1°C) for 15 days



(1°C) for 20 days



(-18°C) for 30 days

There is a significant differences between the characteristics such as having cavities, chewing and taste ($P < 0.05$). For treatments, the characteristics of aroma, tissue and color of the bread inside indicate no significant of the effect of the treatment.

Regarding the cavity feature in the tissue related to -18 °C sample for 20 and 30 days then the temperature of 1 °C for 15 and 20 days had significant differences with other treatments. Mean comparisons indicated that (Table 8) the highest mean is related to the control group. Based on the above data, it can be said that the freezing temperatures and temperatures close to the freezing temperatures damage the protein network and starch polymers, and indicated a smooth structure with fewer cavities that lead to a more continuous and thicker surface.

Since freezing damages the yeast cell and produces revival compounds such as glutathione which causes the weakening of paste and the destruction of the inner tissue of bread. Moreover, the destruction of yeast ultimately leads to the fermentation process which is effective in producing an improper spongy tissue in the product. As a result, less gas bubbles are produced and this causes the decrease in cavities in the paste and also the reduction in the size of the final product. The results of electronic microscopy and the specific volume are consistent with the results obtained by other scientists (Barcenas and Rosell, 2004).

Table 8. Sensory characteristics of the inside bread tissue

Treatment	Taste	Chewing	Aroma	Color of the bread inside	Containing cavities and the granularity of the bread inside	Tissue
(control) C	^{a}14/10	^{a}9/38	^{a}9/00	^{a}9/34	^{a} 9/38	^{a}15/00
(30 days -18°c)S$_{31}$	^{a}14/40	^{a}10/00	^{a}9/00	^{a}9/08	^{c} 7/10	^{a}14/26
(20 days-18°c)S$_{32}$	^{a}14/25	^{a}9/54	^{a}8/00	^{a}9/34	^{bc} 7/56	^{a}15/00
(20 days1°c)S$_{22}$	^{ab}13/50	^{ab}9/00	^{a}9/20	^{a}9/54	^{bc}7/38	^{a}15/00
(15 days1°c)S$_{21}$	^{b}12/75	^{a}9/50	^{a}10/00	^{a}8/88	^{b} 8/04	^{b}13/50
(15 days4° c)S$_{12}$	^{ab}13/25	^{b}8/05	^{a}9/00	^{a}8/84	^{ab} 8/52	^{a}14/25
(10 days4° c)S$_{11}$	^{b}12/75	^{b}8/05	^{a}10/00	^{a}10/00	^{ab}8/48	^{a}14/25

* Same small letters indicate no significance in the column.

In the chewing characteristic, the results of the comparison of the means (Table 8) indicate that the highest mean is related to the with -18° C group with 30 days which was significantly more than the treatments with 4 ° C for 15 days and 4 ° C for 10 days. High moisture content of bread resulted from frozen paste can be due to condensation of water and the presence of ice crystals.

Increase in the amount of freezing water during freezing storage of the paste, can be due to the return of ice crystals. Since the gluten network is denatured in the par-baked bread before freezing, the main reason for the increase in the freezing water is the redistribution of water in the system (Barcenas et al., 2003 and Ribotta et al., 2003).

The comparison of the means in the characteristic of taste (Table 8) indicated that the best taste is related to the -18° C for 30 days, then -18 ° C for 20 days later, and then the control group which had the closest points to each other which probably was frozen due to the higher moisture in the treatments and has a positive effect on the consumer's mouth fee land is consistent the results of Zheng and Lan, 2007 regarding that the higher the moisture is, the better the taste is.

Table 9. Sensory characteristics of the external bread tissue

Treatment	volume	break	Crust property	Crust color	symmetry
(control) C	10.00^{a}	6.80^{a}	2.85^{a}	2.85^{a}	2.70^{a}
(30 days -18°c)S_{31}	8.00^{a}	6.00^{a}	2.40^{a}	2.55^{a}	2.10^{a}
(20 days-18°c)S_{32}	8.46^{b}	6.80^{a}	2.10^{a}	2.55^{a}	1.95^{a}
(20 days1°c)S_{22}	9.30^{ab}	6.00^{a}	1.80^{a}	2.40^{a}	2.10^{a}
(15 days1°c)S_{21}	9.42^{ab}	5.60^{a}	2.25^{a}	2.40^{a}	1.95^{a}
‘15 days4° c)S_{12}	9.67^{a}	7.20^{a}	1.95^{a}	2.25^{a}	2.55^{a}
(10 days4° c)S_{11}	9.86^{a}	7.60^{a}	1.95^{a}	2.25^{a}	2.10^{a}

* Same small letters indicate no significance in the column

The comparison of the mean of the treatments using Duncan test indicated that there is only a significant difference between treatments regarding the characteristic of volume ($P < 0.05$). The highest mean was related to the control group which was significantly higher than -18 °C treatments.

It is probable that due to the damage to the tissue and yeast cells, the production of carbon dioxide by yeast cells in freezing temperatures and close to freezing temperate lead to the loss of the produced gas and ultimately reduce the amount of bread production in the control group. The production of carbon dioxide by the yeast cells was reduced by freezing and freezing storage. This led to the increase in leavening time of the paste, reduction in bread volume and increased hardness of the bread inside (Aibara et al, 2001).

According to the reports, the volume of the bread baked from frozen paste has a great tendency to decrease in comparison to its normal type, which is due to the freezing damage to the yeasts, especially in long periods and temperature fluctuations, which is consistent with (Faridi and Faubion, 1990).

- Conclusion

The results indicated that the physical properties of toast such as the highest specific volume is related to the control group and then the treatment stored 4 °C for 10 days and the lowest specific volume is related to treatments with -18 ° C for 30 and 20 days in which due to the destructive effect of the crystals that are formed in the tissue of the paste, the structure of the paste was damaged and weakened and the paste was not able to hold the gas bubbles and thus the specific volume has decreased.

Analysis of the hardness of the bread inside indicated that the most hardness and staling of bread, it has the longest shelf life of the treatments in -18 °C for 30 and 20 days than the control and other treatments and the reasons are related to the increase of ice crystals and the damage to the protein network and the extraction of amylose from the granular structure.

Regarding the moisture, we concluded that the -18°Cfor 30 days had the highest moisture which was due to the condensation of water resulted from the ice crystals.

In investigating the microstructures of bread, we found that the best treatment was the control group which had the highest number of cavities, porosity and microstructure quality and the worst treatment was related to -18 °C treatment for 30 days which is probably related to the tissue damage caused by freezing and the increase in ice crystals, creating large fibrils of gluten and large polymers of starch.

According to the sensorial characteristics and gradation of pen lists, the highest score of the sensory characteristics of bread, such as chewing, taste of the treatment maintained at a temperature of -18 ° Cfor 30 days that has probably been frozen due to the higher moisture of the treatment and had the lowest score of the sensory characteristics of the interior regarding the cavity. The treatment stored at 1 ° C for 15 days and 1 ° C after 20 days had the lowest total scores and generally regarding the internal and external sensory characteristics of bread the control group has is more desirable and has many holes.

In general, it was concluded that treatment ° 4 °C for 10 days was the best treatment than other treatments because it has the lowest hardness and staling of bread on different days of the test. After the control group, the highest volume and the best structure of the tissue after the control indicated the SEM and in addition, the organoleptic characteristics of the sample from the control group and close to the data of the treatment -18 °C for 30 and then 20 days, had the highest number.

The aim was achieved that a good quality and economical bread can be offered to the market and with the storage conditions to be kept in home freezer and refrigerator temperature some steps were taken to reduce cooling and freezing costs. Whereas, the treatment kept in the refrigerator indicated better results.

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