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The effect of adding improvers on the physical and chemical properties of frozen pizza dough

Dr. Yahya Ismail Joha

(Doctor in the Department of Basic Sciences at Damascus University)

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Abstract:

This research aimed to study the effect of adding two types of flour improvers (ascorbic acid and vital gluten) on the physicochemical and rheological properties of locally produced types of flour (standardized flour and zero flour) prepared for preparing frozen dough. Flour samples were obtained from the central laboratory of the General Organization for Grain Trade, Manufacturing and Storage in the Al-Sabina area. These samples were supplemented with ascorbic acid at a percentage of (100 and 200) ppm and vital gluten at a percentage of (2 and 4) and a mixture of them. Then, physicochemical and rheological tests of the flour were conducted. The dough was prepared and frozen using both quick and slow freezing methods, and stored for (30, 60, 90 and 120) days at a temperature of -18 degrees Celsius. Then the physicochemical and rheological properties of the frozen dough were measured, after which the pizza dough was manufactured and physical, chemical and sensory tests were conducted on it. Adding improvers led to a significant increase in fermentation power, while a negative significant effect of storage time on yeast activity was observed, as the values of fermentation power decreased for all samples in both freezing methods as the frozen storage time increased. The maximum average extensibility resistance of frozen dough was observed to decrease after 120 days of frozen storage, and the extensibility values decreased as the frozen storage process continued. The adhesion values of frozen dough increased in the slow and fast methods. The results showed that adding ascorbic acid improves the ability of the dough to retain gases to strengthen the gluten network, increase the volume of the dough, and reduce the duration of fermentation, so it has finer pores and a homogeneous pulp, while reducing the phenomenon of aging and prolonging the shelf life of the dough. The results of the statistical analysis showed that the optimal ratios for strengthening the dough are 200 ppm ascorbic acid and 4% vital gluten, which gave a positive effect on the quality characteristics of the dough.

Keywords: ascorbic acid, vital gluten, frozen dough.

Introduction:

Food grains and their various products, the most important of which is bread, occupy a major place in human meals all over the world. Wheat occupies the first place among grain crops, due to the cheap price of products produced from wheat flour, which made it a basic place in human meals. Wheat is also grown all over the world under varying conditions to give an abundant crop with high nutritional value, as wheat is produced in 120 countries, and constitutes 19% of the total global food calorie output. Consumer awareness has increased as they are looking for a safe and high-quality product. This interest began with the spread of some modern food products that are traded daily, such as frozen bakery products, which have become increasingly widespread and traded recently. These products are also characterized by being economical and suitable for the working homemaker, which increases competition between companies and bakeries to produce many types of frozen dough is to which many improvers are added. To obtain baking products with high quality and safety characteristics, it is necessary to choose the factors that affect these characteristics. This starts with the primary raw materials such as the type of wheat flour, yeast and improvers, as well as the characteristics of the dough, which include water content, acidity and manufacturing process conditions such as freezing time, temperature and baking time. All of these factors lead to a safe final product.

Research objective:

Improving the physicochemical properties of frozen dough is produced and prepared for pizza making by adding two types of improvers (ascorbic acid and vital gluten).

Materials and research methods:

- **Research materials:**

1-Wheat flour (zero flour 72% extraction).

2- Ascorbic acid (ready-to-use powder from the local market).

3- Vital gluten (ready-to-use powder from the local market).

4- Pizza making ingredients: baker's yeast (ready-to-use powder from the local market), soy oil, emulsifiers, sugar, salt.

These samples were supplemented with ascorbic acid at a rate of (100 and 200) ppm and with vital gluten at a rate of (2 and 4) % and a mixture of them (Table No. 1-1).

Table (1-1): Coding of samples of zero flour fortified with improvers and a mixture of them.

Sample number	Sample characterization
1	zero flour 72% extraction
2	ascorbic acid 100ppm
3	Ascorbic acid 200ppm
4	Vital gluten 2%
5	Vital gluten 4%
6	Ascorbic acid 100ppm + vital gluten 2%
7	Ascorbic acid 100ppm + vital gluten 4%
8	Ascorbic acid 200ppm + vital gluten 2%
9	Ascorbic acid 200ppm + vital gluten 4%

Reference study:

Frozen dough is defined as a food product prepared from wheat flour or other grain flour and water, and optional materials suitable according to the type and subjected to heat treatment to stop the activity of the yeast after obtaining appropriate fermentation, without ripening or changing its color, as it is shaped as desired, and then frozen quickly to -18 °C center temperature (Ribotta et al., 2006).

There are also materials added to the flour, which affect the rheological properties of the dough, which is reflected in the quality of the final product, and include emulsifying agents, fatty materials, glucose syrup, milk and yeast nutrients, etc. (Kenny et al., 2001).

Ascorbic acid (AA) (C6H8O6) is also known as vitamin C, is widely distributed in nature, and is found in abundance in citrus fruits and peppers. It has been known to have special physiological and nutritional importance. Ascorbic acid does not only work as a vitamin, but it is also added to food products to improve their quality. It has been used for many years in the food industry as a food additive. In addition to its antioxidant properties, ascorbic acid is characterized by its improving effect on flour, which has made it the most important improver in the bakery industry, as it oxidizes the (SH-) groups in the dough, making the resulting dough stronger and drier with an increase in the volume of the loaf (Shewry and Tatham, 2002). Ascorbic acid may create (disulfide) bonds that strengthen the gluten network, thus improving the gas retention of the dough (Cauvain *et al.,* 2005). Furthermore, ascorbic acid provides other benefits for bread making, such as providing resistance to the dough during mixing, and increasing the dough volume during the first 10–12 min of baking due to the increased fermentation rate, i.e. after the loaf is placed in the oven, before the crust hardens, and browns. Ascorbic acid cannot increase the oxidation of the dough. Therefore, ascorbic acid is most suitable for dough making systems at any time (Cauvain *et al.,* 2015). Ascorbic acid has a noticeable effect on strengthening the gluten network due to the increased cross-linking of its proteins, and the oxidative effect occurs mostly during the resting of the dough, and the mechanism by which ascorbic acid improves the rheological properties of flour and water dough is mostly due to the development of its ability to donate electrons and reactive products such as O-2 (Novotná and Hrušková, 2003).

Pizza Dough:

Modern pizza, as we know it today, originated in Naples, Italy as an affordable fast food for working-class Neapolitans; however, pizza in its simplest form as a flatbread is now popular all over the world and is a favorite food for a large number of urban dwellers with different types of pizza based on local ingredients and flavors (Helstosky, 2008). Pizza consumption has increased significantly over the past decade, an increase of more than 1.5 times in 12 years (Statista, 2020). Pizza dough has evolved into one of the most beloved baked foods in the world (Moore, 2009). Pizza is a complete meal for all nutritional requirements, as its components include carbohydrates, proteins, and vitamins in the diet (Redl, 2003). Pizza dough is a flatbread that can be leavened by chemical processes or yeast. Flatbread is made from ground grains, and wheat is one of the most common grains. The unique interaction between the proteins present in ground wheat flour and water makes this grain a versatile ingredient for making bread. Pizza is a very popular fast food and is high in calories. Pizza dough can be made from wheat flour, corn flour, as well as wheat flour with gluten, as the dough indicates to the best shape and quality of pizza. Usually circular and covered with tomato sauce and often cheese, with other optional toppings, pizza is one of the most commonly fried products (Lorns, 1995). Pizza consists of a variety of ingredients, such as eggs, pineapple, bananas, coconut, sauerkraut, eggplant, kimchi, lamb, couscous, chicken, fish, shellfish and chicken and unconventional spices such as curry and paprika. When making pizza dough, the amount of flour needed to complete the dough varies, depending on humidity and temperature (). Studies have focused on preparing pizza from locally available raw materials and evaluating the effect of ingredients on the quality of the prepared pizza. Wheat flour, dry gluten, dough powder, yeast, sugar, salt and soybean oil were used in preparing wheat flour pizza. Initially, the necessary ingredients were properly mixed and the dough was made using water. The dough was rested for 2 h, processed for 10 min, rested again for 1 h and then first fermentation at for 10-15 min and final fermentation at for 1 h and then the dough was placed in a baking oven at for 20 min. After the dough was kneaded, the sauce was added. A panel of testers tested the prepared pizzas. The pizza made with wheat flour was more acceptable in terms of colour, flavour, texture and overall acceptability (Ridgaway, 2005). Many additives have been used to improve the quality and shelf life of pizza dough. Stabilizers or hydrocolloids are widely used in the dough industry to improve water-holding capacity, modify its texture, volume and cell structure and maintain product quality during storage. Hence, these additives can also be used in frozen dough to reduce the negative effects on starch and gluten to preserve the frozen dough for its intended use. Stabilizers can be classified into seven different categories such as proteins, natural plant secretions, seaweed extracts, and pectin and cellulose derivatives. Gums are a group of naturally occurring sugars. They increase the water-holding capacity and delay moisture migration in the dough. Awareness has gradually encouraged all pizza industry players to use freezers not only to improve the quality of the dough but also to ensure higher quality and safety of all topping ingredients (Holcomb, 2003). Today, in addition to refrigeration (keeping food at a temperature between 0°C and +10°C), freezing is increasingly used to preserve food and dough, which involves placing food at a temperature that can range from -7°C to -18°C depending on the type of food, thus keeping it at -10°C (Yi and Kerr, 2009). Although the freezing method of pizza dough extends the shelf life of food products, several problems arising from the product made from frozen dough have been described, including gradual loss of dough strength, decreased carbon dioxide holding capacity, longer fermentation time, decreased yeast activity, reduced loaf volume, and deterioration of the texture of the final product (Meng, 2016). Moreover, during the defrosting phase, part of the nutritional and sensory value of the food is lost, as well as the rheological values of the pizza dough (Akbarian et al., 2016). In fact, frozen pizza dough samples cannot reach a similar result to those obtained from fresh pizza dough, which is more elastic and extensible, and ferments and cooks better. Usually, what negatively affects the quality of frozen products is not the low storage temperature but the speed of freezing, which is the time, required the food interior to reach the desired temperature (Giannou and Tzia, 2007). In general, the factors affecting the quality of frozen products can be summarized as follows: the ingredients used in the dough composition and specifically the effect of emulsifiers, fats, enzymes or yeast (Mandala and Sotirakoglou, 2005). The dough composition greatly influences the specific volume and core hardness, and the type of wheat flour used in the production of frozen dough is crucial for imparting the desired product properties after prolonged frozen storage. The use of improvers such as vital gluten and guar gum improves the specific volume and shape ratio but this has not been conclusive because excessive use of hydrocolloids may It causes instability of dough texture due to interference with gluten proteins or starch polymer matrix, and the problems of low CO_2 production or gluten network damage can be overcome by adding improvers. However, there is no specific improver that solves all the problems related to frozen dough products (Meng, 2016). On the other hand, it has been confirmed that freezing process parameters such as freezing rate and storage time have significant effects on the properties of frozen products (Yi and Kerr, 2009), where ice crystal formation and recrystallization, water redistribution, yeast destruction, and gluten network and starch granule damage may be the direct causes that lead to the change in dough properties. Dough frozen at relatively slow freezing rates and stored at higher temperatures (-10 to -20 °C) was softer, had higher volume and lighter color, yet had a greater tendency to stick. In the frozen dough industry, protection from the effects of freezing on the viability of yeast cells is a major concern, therefore, slow cooling in conventional freezers is the preferred technology, which provides much faster cooling, but is supposed to be more detrimental to the survival of yeast cells in dough pieces (Neyreneuf and Delpuech, 1993). These food proteins can be said to be macronutrients and dietary fibers for their gluten-containing counterparts (Calvo-Lerma, 2019). A cross-sectional study analyzing nutritional differences between hundreds of gluten-free and gluten-rich products showed that the latter are higher in protein, especially in flour, bread, pasta and pizza (Cornicelli, 2018), so replacing wheat flour with whole-wheat flour is a straightforward way to improve the nutritional properties of pizza. (Syed Saif Alam and Deepti Bharti, 2022) replaced wheat flour with whole-wheat flour 100:0, 75:25, 50:50:25:75, and 0:100) in pizza dough. It was evident that substitution of wheat flour with whole-wheat flour resulted in the development of golden yellow pizza, decreased crust lightness, and increased yellowness index upon continuous substitution of wheat flour with whole-wheat flour. It was also observed that the pore size of pizza dough decreased while the port density increased. (Syed Saif Alam and Deepti Bharti, 2022) in a previous study on the porosity structure of pizza dough crumbs confirmed that the structure has the ability to influence, the texture and the cohesion and elasticity were comparable for all the prepared samples. Interestingly, the hardness and chewiness values showed an increasing trend. The texture properties met the requirements of a wide age group. The pizza dough developed using 50% whole-wheat flour and 50% wheat flour showed acceptable viscosity and elasticity properties. (Syed Saif Alam and Deepti Bharti, 2022).

Measurement of rheological properties of frozen dough:

- Expansion resistance of frozen dough is using the slow and rapid methods:

The rheological properties were measured using a (Texter Analyser) device for frozen dough samples, and the results of the expansion resistance of frozen dough using the slow and rapid methods were recorded in Tables (1 and 2), respectively. The results of the ANOVA analysis to determine the significant differences between the averages of the values of the resistance to expansion of the dough frozen by the slow method of zero flour fortified with improvers showed a decrease in the maximum average resistance to expansion of the frozen dough after 120 days of frozen storage, as it reached (32.90 and 28.59) g in the control sample stored for 120 days, while it was (54.53 and 48.36) g when frozen for 30 days in the slow method and the fast method, respectively. The decrease in the resistance to expansion may indicate a deterioration in the gluten network (Yi Kerr and, 2009). In addition, the added improvers (ascorbic acid and vital gluten) helped improve the values of the resistance to expansion of the frozen dough, as the values reached (57.90 and 51.30) g when adding the highest concentrations of improvers (sample No. 9 fortified with 200 ppm ascorbic acid and 4%) vital gluten during the storage period of the dough for 30 days. On the other hand, the values of the resistance to expansion of the dough frozen by the slow method were higher than those of the dough frozen by the quick method. Microscopic studies of frozen dough showed that during freezing there are also negative effects on the structure of the dough, as the gluten network collapses when exposed to freezing and thawing, and this was linked to changes in the rheological properties of the dough (Esselink et al., 2003).

Table (1): Values of the resistance to expansion (g) of dough frozen by the slow method.

Storage period				
day120	**day90**	**day60**	**day30**	**Sample No./Days**
0.71 ± 32.90^{a}	0.59 ± 40.08^{a}	0.64 ± 48.55^{a}	0.56 ± 54.53^{a}	1
0.58 ± 32.95^{a}	1.08 ± 40.15^{a}	1.09 ± 48.56^{a}	1.28 ± 54.70^{b}	2
0.55 ± 32.93^{a}	0.72 ± 40.20^{a}	0.60 ± 49.90^{b}	0.17 ± 55.28^{c}	3
0.45 ± 33.80^{b}	1.14 ± 40.50^{b}	0.54 ± 48.80^{c}	0.97 ± 55.80^{d}	4
0.25 ± 33.97^{c}	0.50 ± 40.58^{b}	0.64 ± 48.85^{c}	0.22 ± 55.85^{d}	5
0.52 ± 34.85^{d}	1.22 ± 42.27^{c}	1.09 ± 49.96^{b}	1.58 ± 57.25^{e}	6
0.55 ± 34.93^{d}	0.12 ± 42.56d	0.30 ± 50.25^{d}	0.12 ± 57.88^{f}	7
0.79 ± 36.85^{e}	1.14 ± 44.50^{e}	0.51 ± 51.85^{e}	0.55 ± 57.86^{f}	8
0.11 ± 36.90^{e}	0.34 ± 44.58^{e}	0.44 ± 51.90^{e}	0.33 ± 57.90^{f}	9

*Similar letters in the same column indicate no significant differences at the P≤0.05 confidence level.

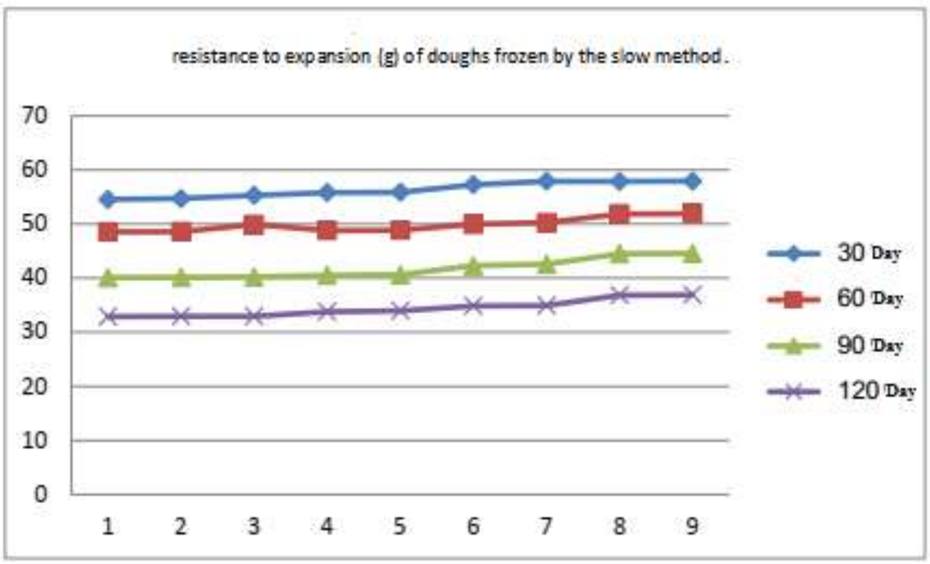

Figure (1): Values of the resistance to expansion (g) of dough frozen by the slow method.

Table (2): Values of the resistance to expansion (g) of dough frozen by the rapid method.

Storage period				
day120	**day90**	**day60**	**day30**	**Sample No./Days**
± 28.59 0.78[a]	0.22 ± 32.80[a]	0.60 ± 42.63[a]	1.14 ± 48.36[a]	1
± 29.26 0.19[b]	0.15 ± 32.95[b]	0.44 ± 42.84[b]	0.63 ± 48.55[b]	2
± 29.65 0.21[c]	0.52 ± 33.05[b]	0.25 ± 42.86[b]	1.18 ± 48.52[b]	3
± 29.30 0.12[b]	0.17 ± 33.42[c]	0.49 ± 43.17[c]	0.73 ± 48.62[b]	4
± 29.59 0.78[b]	0.45 ± 33.50[c]	0.55 ± 43.20[c]	1.10 ± 49.55[c]	5
± 30.25 0.33[d]	0.55 ± 35.10[d]	0.69 ± 44.85[d]	0.33 ± 49.60[c]	6
± 30.35 0.14[d]	0.20 ± 35.66[e]	0.34 ± 44.86[d]	0.44 ± 49.82[d]	7
± 31.20 0.15[e]	0.65 ± 36.22[f]	0.15 ± 46.22[e]	0.25 ± 50.02[e]	8
± 31.60 0.45[f]	0.11 ± 36.85[g]	0.60 ± 46.50[f]	0.44 ± 51.30[f]	9

*Similar letters in the same column indicate no significant differences at the P≤0.05 confidence level.

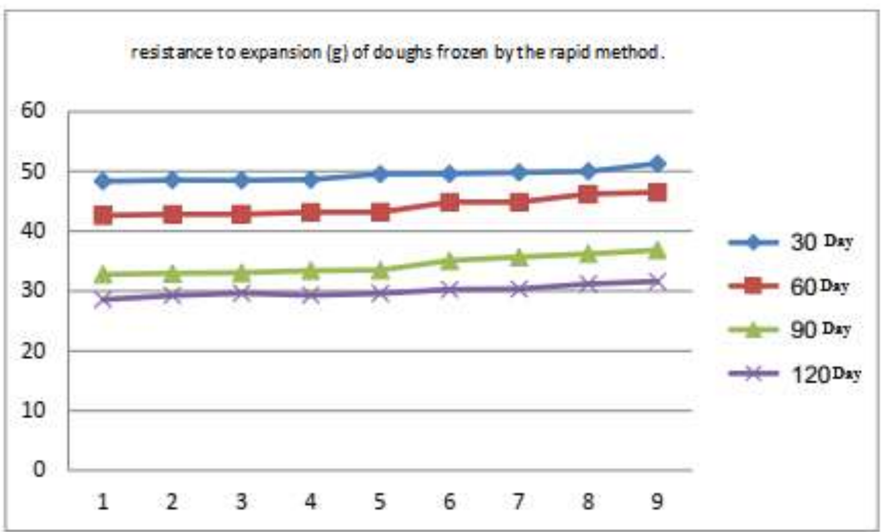

Figure (2): Values of the resistance to expansion (g) of dough frozen by the rapid method.

2-Expansion capacity of dough frozen by slow and fast methods:

Tables (3 and 4) show the values of extensibility of dough frozen by slow and fast methods, respectively. The results showed significant differences between the studied storage periods of all samples and between the two freezing methods, as the values of the extensibility decreased with the continuation of the frozen storage process, and ranged in the control samples between (70.65-80.00) mm, while in the samples fortified with 200 ppm ascorbic acid and 4% vital gluten, they ranged between (72.55-83.10) mm in the slow freezing method. On the other hand, in the control samples, they ranged between (48.55-74.15) mm, and in sample No. 9 fortified with 200-ppm ascorbic acid and (4) % vital gluten, they ranged between (49.95-75.85) mm in the quick-freezing method. The results of this study were consistent with previous research, as they showed that the recrystallization of ice and the migration of water in the dough also affect the structure of the dough, and frozen storage for long periods changes the gluten protein matrix, which leads to Dough weakening and gas retention are reduced, in addition, yeast membrane injury resulting from freezing and thawing releases cellular chemicals that have detrimental effects on dough structure (Rojas et al., 2000).

Table (3): Expansion values (mm) for dough frozen by slow method.

Storage period				
day 120	**day90**	**day60**	**day30**	**Sample No./Days**
0.71 ± 70.65^{a}	0.11 ± 74.50^{a}	0.26 ± 77.80^{a}	0.12 ± 80.00^{a}	1
0.24 ± 70.85^{b}	0.70 ± 74.85^{b}	0.61 ± 78.25^{b}	0.50 ± 80.60^{b}	2
0.61 ± 70.90^{b}	0.15 ± 74.80^{b}	0.30 ± 78.55^{c}	0.11 ± 80.65^{b}	3
0.25 ± 71.35^{c}	0.12 ± 75.25^{c}	0.22 ± 78.60^{c}	0.38 ± 80.55^{b}	4
0.11 ± 71.85^{d}	0.56 ± 75.85^{d}	0.21 ± 78.85^{d}	0.44 ± 80.60^{b}	5
0.44 ± 71.85^{d}	0.10 ± 75.80^{d}	0.41 ± 79.35^{e}	0.52 ± 81.20^{c}	6
0.22 ± 72.05^{e}	0.11 ± 76.30^{e}	0.32 ± 79.55^{f}	0.52 ± 81.25^{c}	7
0.20 ± 72.10^{e}	0.45 ± 76.65^{f}	0.22 ± 79.50^{f}	0.66 ± 82.85^{d}	8
0.21 ± 72.55^{f}	0.50 ± 76.90^{g}	0.65 ± 79.85^{g}	0.15 ± 83.10^{e}	9

*Similar letters in the same column indicate no significant differences at the P≤0.05 confidence level.

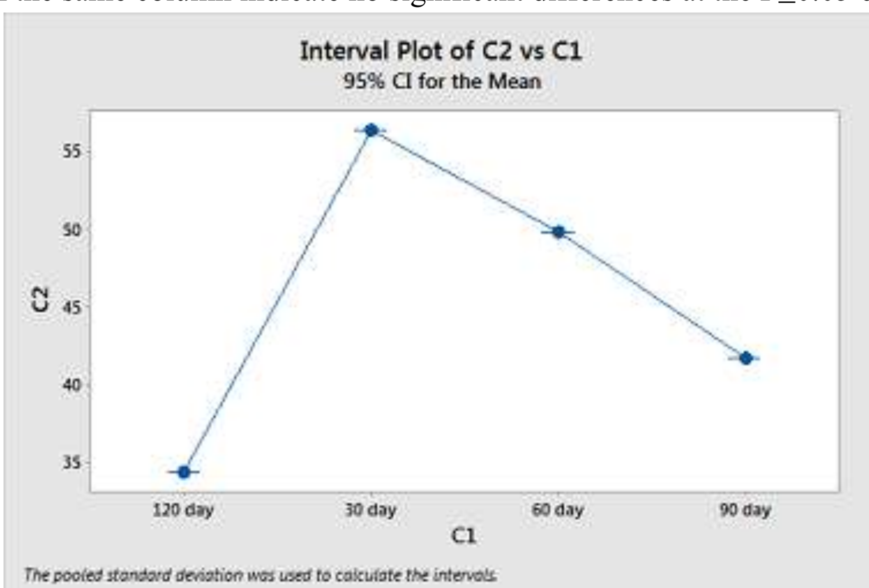

Figure (3): Values of extensibility (mm) for dough frozen by the slow method (c1 storage period, c2 extensibility).

Table (4): Expansion values (mm) for dough frozen by the rapid method.

Storage period				
day120	day90	day60	day30	Sample No./Days
0.46 ± 48.55[a]	0.31 ± 54.15[a]	0.59 ± 63.60[a]	0.65 ± 74.15[a]	1
0.22 ± 48.85[b]	1.03 ± 54.35[b]	0.24 ± 64.05[b]	0.15 ± 74.65[b]	2
0.13 ± 49.20[c]	0.95 ± 54.75[c]	0.49 ± 64.45[c]	0.55 ± 74.90[c]	3
0.31 ± 49.10[c]	0.69 ± 54.40[b]	0.55 ± 63.85[d]	0.97 ± 74.60[b]	4
0.42 ± 49.55[d]	0.33 ± 54.80[c]	0.22 ± 64.10[b]	0.15 ± 74.70[b]	5
0.15 ± 49.35[e]	0.20 ± 55.30[d]	0.34 ± 64.40[c]	0.25 ± 74.95[c]	6
0.33 ± 49.60[f]	0.35 ± 55.65[e]	0.41 ± 64.80[d]	0.22 ± 74.95[b]	7
0.21 ± 49.65[f]	0.29 ± 55.60[e]	0.49 ± 64.90[d]	0.66 ± 75.40[d]	8
0.45 ± 49.95[g]	0.11 ± 56.10[f]	0.30 ± 65.60[e]	0.44 ± 75.85[e]	9

*Similar letters in the same column indicate no significant differences at the P≤0.05 confidence level.

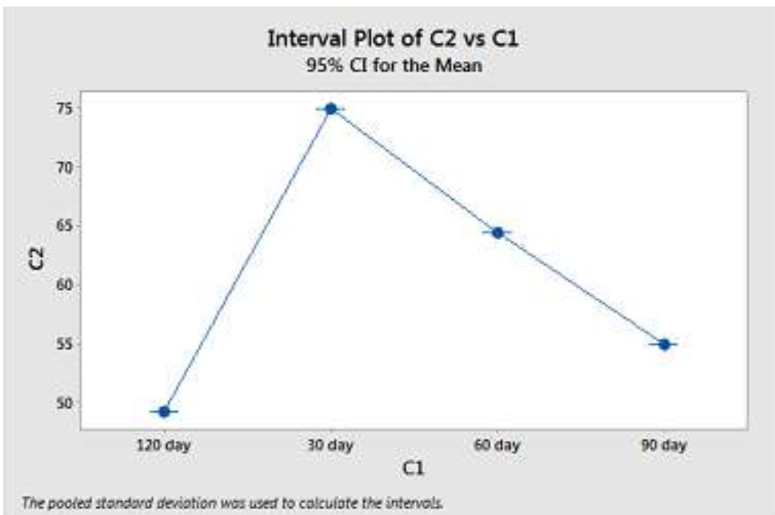

Figure (4): Values of extensibility (mm) for dough frozen by the quick method (c1 storage period, c2 extensibility).

-Adhesion ratio of dough frozen by slow and fast method:

Tables (5 and 6), The results of the analysis showed that the values of dough adhesion ratio were significantly affected by storage time, as the adhesion values of dough frozen by slow method increased, and ranged between (88.97-124.11 and 80.24-110.15) g for the control samples and samples No. (9) fortified (with ascorbic acid 200ppm and vital gluten 4%) when stored from 30 days to 120 days, respectively, compared to (88.74-105.46 g and 80.75-95.88 g) for dough frozen by fast method. The increase in the stickiness values of frozen dough may be due to the disruption of the gluten network bonds caused by the mechanical action of ice crystals (Havet et al., 2000), and previous studies have also shown that the frozen storage period had a negative effect on the dough toughness, softness and stickiness (Angioloni Meziani et al., 2008et al., 2012; Esteller et al., 2004). Changes in disulfide, hydrogen and ionic bonds occur during frozen storage, leading to a gradual disruption of the dough structure. Therefore, the decrease in the intermolecular attraction between the components of frozen dough during storage may be the cause of dough aggregation and increased stickiness.

Table (5): Values of the Adhesion ratio (g) for dough frozen by the slow method.

Storage period				
120 day	**90 day**	**60 day**	**30 day**	**Sample No./Days**
124.11 ± 1.79^{a}	112.29 ± 0.96^{a}	98.64 ± 0.16^{a}	88.97 ± 0.68^{a}	**1**
121.87 ± 1.48^{b}	111.86 ± 0.68^{b}	96.21 ± 0.30^{b}	88.16 ± 0.49^{b}	**2**
120.68 ± 0.50^{c}	111.75 ± 0.22^{b}	94.96 ± 0.46^{c}	88.17 ± 1.02^{b}	**3**
122.56 ± 0.45^{d}	111.12 ± 0.55^{a}	98.48 ± 0.37^{d}	88.19 ± 0.91^{b}	**4**
121.21 ± 0.55^{c}	110.50 ± 0.12^{c}	96.25 ± 0.16^{b}	88.10 ± 0.55^{b}	**5**
120.77 ± 0.40^{c}	110.25 ± 0.33^{d}	95.21 ± 0.33^{c}	86.15 ± 0.44^{c}	**6**
118.85 ± 0.22^{c}	$109.92 \pm 0.65e$	94.88 ± 0.25^{c}	85.87 ± 0.25^{d}	**7**
114.55 ± 1.45^{f}	109.88 ± 0.42^{c}	92.58 ± 0.41^{f}	82.10 ± 0.56^{c}	**8**
110.15 ± 1.20^{g}	108.09 ± 0.36^{f}	90.60 ± 0.15^{g}	80.24 ± 0.32^{f}	**9**

*Similar letters in the same column indicate no significant differences at the P≤0.05 confidence level.

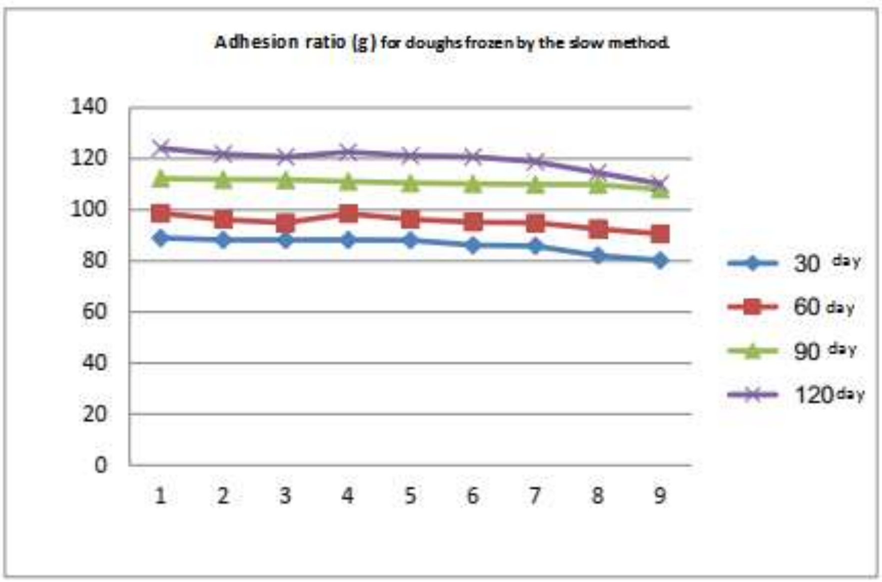

Figure (5): Values of the adhesion ratio (g) for dough frozen by the slow method

Table (6): Values of the **Adhesion ratio** for dough frozen by the quick method.

Storage period				
120 day	90 day	60 day	30 day	Sample No./Days
105.46 ± 0.91ᵃ	100.66 ± 1.94ᵃ	98.35 ± 0.45ᵃ	88.74 ± 0.43ᵃ	1
102.91 ± 0.65ᵇ	100.28 ± 0.67ᵇ	98.15 ± 1.15ᵇ	88.15 ± 0.58b	2
102.44 ± 0.95ᶜ	100.25 ± 0.80ᵇ	98.10 ± 0.61ᵇ	86.41 ± 0.66ᶜ	3
103.01 ± 1.88ᵈ	100.15 ± 1.73ᵇ	98.05 ± 0.71ᵇ	88.24 ± 0.59ᵇ	4
100.55 ± 0.43ᵉ	99.85 ± 0.88ᶜ	98.00 ± 0.44ᵇ	86.35 ± 0.33ᶜ	5
100.45 ± 0.35ᵉ	96.40 ± 0.45ᵈ	96.85 ± 0.35ᶜ	84.15 ± 0.68ᵈ	6
98.42 ± 0.65ᶠ	94.25 ± 0.22ᵉ	96.21 ± 0.65ᵈ	82.01 ± 0.65ᵉ	7
98.33 ± 0.22ᶠ	90.50 ± 0.44ᶠ	96.00 ± 0.11ᵉ	82.55 ± 0.23ᶠ	8
95.88 ± 0.66ᵍ	88.20 ± 0.56ᵍ	94.35 ± 0.40ᶠ	80.75 ± 0.44ᵍ	9

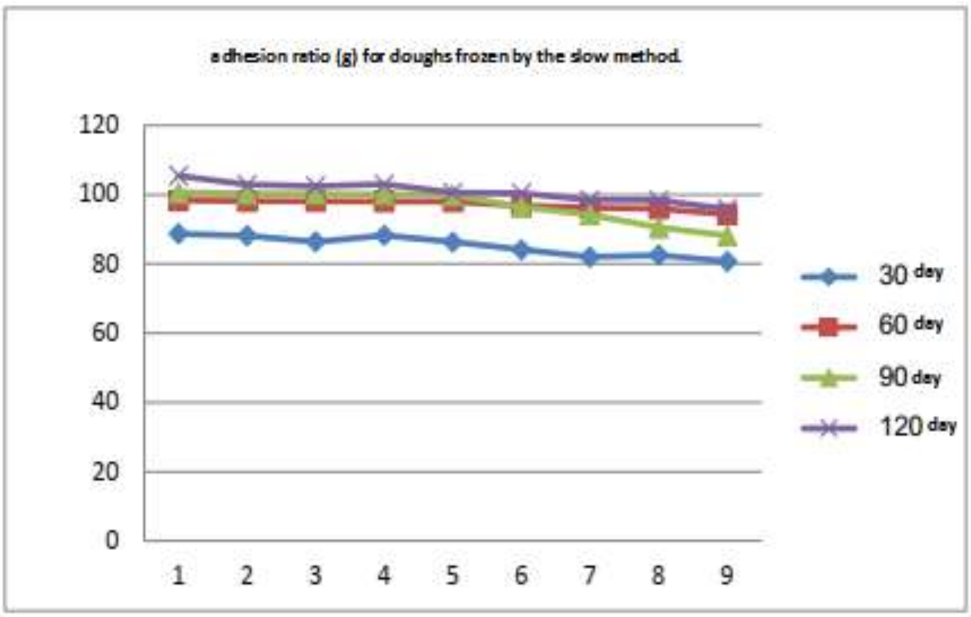

Figure (6): Values of the adhesion ratio (g) for dough frozen by the quick method.

Physical, chemical and sensory properties of pizza prepared from frozen dough and fortified with improvers:

- Physical properties of pizza dough:

In table (7-8) The results of the study of the physical properties of frozen pizza dough fortified with improvers (ascorbic acid and vital gluten) and a mixture of them showed that the dough volume was significantly affected by the addition of improvers at a confidence level ($P \leq 0.05$) and its values ranged between (169.69-169.56) $cm^{3.}$ This is due to ascorbic acid, which improves the dough's ability to retain gases and strengthen the gluten network, increases the dough volume, reduces the fermentation period, and improves the volume of the resulting dough, making it have finer pores and a homogeneous core, while reducing the phenomenon of dormancy and extending the shelf life of the dough. This is consistent with the results of (Renzetti S and Dal Bello F, 2008). Some studies have shown that long storage periods are associated with a decrease in the volume of the final product. (Giannou and Tzia, 2007) found that the quality of frozen dough It deteriorates rapidly during the first months of frozen storage but remains stable for up to 9 months of storage. The same effect was observed for the specific volume, where its values ranged between (1.75-1.76 (cm^3/g) when improving the dough, as the freezing rate and temperature have an effect on the specific volume. In previous studies, the specific volume of frozen dough differed between storage periods of 30 days and 180 days. The frozen dough stored for 180 days was smaller in volume, which is consistent with (Kenny, 2001). Significant differences were observed between the control and the percentages of improving additions in relation to the weight, where its values ranged between (96.33-96.79) g.

Table (7): Physical properties of frozen pizza dough by the slow method.

Specific Volume (cm^3/g)	Volume $(cm)^3$	Weight (g)	Sample No.
0.12±1.76^b	0.12± 169.56^b	0.01±96.33^c	1
0.22± 1.75^a	0.22± 169.58^a	0.01±96.30^a	2
0.32± 1.75^c	0.32± 169.59^C	0.01±96.44^c	3
0.42± 1.75^a	0.42± 169.61^a	0.05±96.54^c	4
0.12± 1.75^e	0.12± 169.63^e	0.01±96.64^c	5
0.42± 1.75^b	0.42± 169.65^b	0.04±96.72^a	6
0.02± 1.75^e	0.02± 169.67^e	0.05±96.74^c	7
0.32± 1.75^b	0.32± 169.68^b	0.02±96.77^c	8
0.12± 1.75^b	0.52± 169.69^{ab}	0.02±96.79^c	9

Table (8): Physical properties of frozen pizza dough made by the quick method.

Specific Volume (cm^3/g)	Volume $(cm)^3$	Weight (g)	Sample No.
0.12±1.85^b	0.12± 159.46^b	0.01±86.35^a	1
0.22± 1.85^a	0.22± 159.48^a	0.01±86.40^a	2
0.32± 1.85^c	0.32± 159.49^C	0.05±86.41^a	3
0.42± 1.85^a	0.42± 159.51^a	0.01±86.44^a	4
0.12± 1.85^e	0.12± 159.53^e	0.01±86.50^a	5
0.42± 1.85^b	0.42± 159.55^b	0.05±86.54^a	6
0.02± 1.85^e	0.02± 159.57^e	0.02±86.64^c	7
0.32± 1.85^b	0.32± 159.58^b	0.01±86.74^a	8
0.12± 1.85^b	0.52± 159.59^{ab}	0.01±86.78^a	9

Chemical properties of pizza dough:

Tables (9 and 10) show the chemical properties of frozen pizza dough fortified with two types of improvers (ascorbic acid and vital gluten) and a mixture of them. Adding improvers to frozen pizza dough fortified with two types of improvers (ascorbic acid and vital gluten) and a mixture of them did not affect the percentage of moisture at a confidence level ($P<0.05$), and it ranged in pizza dough frozen by the slow method between (14.15-14.38) %, and the fast method between (13.10-13.56) %. In a previous study, the main effect of frozen storage indicated a decrease in the moisture content of the final product from one day to 60 days after frozen storage (Asghar et al., 2007). The percentage of ash increased with the addition of improvers to the frozen and fortified pizza dough, and ranged in the frozen pizza dough made using the fast method between (0.62-0.77) percentage and the slow method between (0.72-0.77) percent. These results are consistent with (Martin, 2003), as the percentage of ash increased with the increase in the percentage of improvers added (Azizi et al., 2006). The protein content also increased with the increase in the addition rates of ascorbic acid, vital gluten and a mixture of them, reaching a value of (11.81) % for the slow-frozen pizza dough, while the fast-frozen pizza dough reached (10.81) %, which is consistent with the results of (Emire,2015) and (Vetrimani et al.,2005). It is necessary to add vital gluten to the dough to obtain products rich in protein. The percentage of fiber increased significantly with the addition of vital gluten to reach (11.58) percentage for the slow-frozen pizza dough, while the fast-frozen pizza dough reached (10.58) percentage, which is consistent with the research of (Vetrimani et al., 2005). As for the lipid content, it increased with the addition of improvers, ranging between (23.40-23.56) % for the slow-frozen pizza dough, while the fast-frozen pizza dough ranged between (22.41-22.57) % This is consistent with the results of (Daramola, B.and Asunni, 2006).

Table (9): Chemical properties of slow-frozen pizza dough.

Lubricants (%)	Protein (%)	Fiber (%)	Ash (%)	Moisture (%)	Sample No.
23.41±0.02	11.21±0.04^{c}	10.31 ± 0.22^{a}	0.72 ± 0.03^{a}	14.24 ± 0.23^{a}	1
23.40±0.02	11.35 ±0.03^{ba}	10.29 ± 0.15^{a}	0.75 ± 0.10^{a}	14.38 ± 0.02^{a}	2
23.49±0.02	11.44±0.07^{da}	10.33 ± 011^{a}	0.75 ± 0.05^{a}	14.15 ± 0.11^{a}	3
23.46±0.02	11.41±0.04^{b}	11.12 ± 0.25^{b}	0.77 ± 0.01^{a}	14.36 ± 0.20^{a}	4
23.47±0.02	11.52±0.03^{a}	11.75 ± 0.05^{c}	0.76 ± 0.02^{a}	14.26 ± 0.15^{a}	5
23.54±0.02	11.52±0.02^{c}	11.15 ± 0.26^{b}	0.77 ± 0.04^{a}	14.29 ± 0.01^{a}	6
23.53±0.02	11.55 ±0.03^{ba}	11.81 ± 0.65^{c}	0.72 ± 0.09^{a}	14.21 ± 0.10^{a}	7
23.54±0.02	11.56±0.07^{da}	11.11 ± 0.14^{b}	0.73 ± 0.11^{a}	14.31 ± 0.12^{a}	8
23.56±0.02	11.58±0.05^{c}	11.77 ± 0.33^{c}	0.72 ± 0.05^{a}	14.20 ± 0.02^{a}	9

Table (10): Chemical properties of quick-frozen pizza dough.

Lubricants (%)	Fiber (%)	Protein (%)	Ash (%)	Moisture (%)	Sample No.
0.02±22.42	0.05±10.27[e]	0.22 ± 10.21[a]	± 0.68 0.03[a]	0.23 ± 13.34[a]	1
0.02±22.41	10.26 0.03±[fa]	0.15 ± 10.19[a]	± 0.69 0.10[a]	0.02 ± 13.48[a]	2
0.02±22.44	0.07±10.35[d a]	011 ± 10.23[a]	± 0.67 0.05[a]	0.11 ± 13.35[a]	3
0.02±22.47	0.04±10.42[b]	0.25 ± 10.12[b]	±0.68 0.01[a]	0.20 ± 13.56[a]	4
0.02±22.46	0.03±10.44[a]	0.05 ± 10.75[c]	± 0.67 0.02[a]	0.15 ± 13.46[a]	5
0.02±22.50	0.02±10.46[c]	0.26 ± 10.15[b]	± 0.69 0.04[a]	0.01 ± 13.39[a]	6
0.02±22.51	10.56 0.03±[fa]	0.65 ± 10.81[c]	± 0.72 0.09[a]	0.10 ± 13.51[a]	7
0.02±22.56	0.07±10.55[d a]	0.14 ± 10.11[b]	± 0.73 0.11[a]	0.12 ± 13.21[a]	8
0.02±22.57	0.04±10.58[b]	0.33 ± 10.77[c]	± 0.62 0.05[a]	0.02 ± 13.10[a]	9

Sensory properties of pizza dough:

Frozen pizza dough was evaluated by the slow and fast method by a panel of testers working in the field of scientific research at the Central Grain Laboratory in the Sabina region. Nine samples of pizza dough were presented to the testers. The members of the test panel were asked to rate the different types of pizzas presented to them on a 9-point preference scale with ratings: 98. = very good, 8.8 = excellent, 8.7 = very good, 68. = good, 58. = acceptable, 8.4 = average, 8.3 = I like it, 8.2 = I don't like it and 8.1 = I don't like it at all. The results of Tables (12-13) showed the sensory characteristics of the frozen pizza dough prepared using the slow and fast methods, respectively. An increase in the degree of taste was observed with increasing the percentages of adding the two types of improvers and a mixture of them, and it ranged between (8) for the control sample and (8.9) when adding ascorbic acid 200 ppm and vital gluten (4) % to the frozen pizza dough prepared using the fast and slow methods. The texture values of the frozen pizza dough in the fast method ranged between (8.1-8.9) while the slow method ranged between (8.9-8.2), while the odor results for the pizza dough in the slow method ranged between (8.4-8.8) while the fast method ranged between (8.8-8.2), and this is due to the added improvers and their positive effect on the texture and acceptance criteria, and this is consistent with the results of (Sarwar Inam et al., 2009) who indicated that the sensory properties of the dough changed with increasing the addition ratios, and this appeared clearly in the texture and as for the general acceptance, the general acceptance increased with increasing the addition ratios, so all the experimental samples were acceptable.

Table (11): Sensory properties of frozen pizza dough in the slow method.

General acceptance	Smell	Taste	Texture	Sample number
8.4 ± 0.2^{d}	8.4 ± 0.3^{ba}	8.0 ± 0.3^{ca}	8.2 ± 0.3^{d}	1
8.3 ± 0.1^{d}	8.3 ± 0.2^{d}	8.2 ± 0.1^{d}	8.4 ± 0.3^{cd}	2
8.2 ± 0.3^{a}	8.2 ± 0.1^{cd}	8.3 ± 0.2^{d}	8.5 ± 0.2^{ab}	3
8.3 ± 0.6^{d}	8.2 ± 0.2^{d}	8.4 ± 0.1^{d}	8.6 ± 0.3^{cd}	4
8.6 ± 0.2^{d}	8.6 ± 0.2^{d}	8.5 ± 0.2^{d}	8.6 ± 0.7^{cd}	5
8.7 ± 0.5^{d}	8.7 ± 0.2^{d}	8.6 ± 0.2^{d}	8.7 ± 0.3^{e}	6
8.7 ± 0.2^{d}	8.7 ± 0.4^{d}	8.7 ± 0.2^{d}	8.8 ± 0.2^{cd}	7
8.9 ± 0.6^{c}	8.8 ± 0.5^{a}	8.8 ± 0.2^{d}	8.9 ± 0.7^{b}	8
8.9 ± 0.1^{b}	8.8 ± 0.2^{d}	8.9 ± 0.2^{d}	8.9 ± 0.4^{d}	9

Table (12): Sensory properties of frozen pizza dough in the quick method.

General acceptance	Smell	Taste	Texture	Sample number
8.2 ± 0.4^{c}	8.2 ± 0.3^{ba}	8.0 ± 0.3^{ca}	8.1 ± 0.3^{d}	1
8.3 ± 0.1^{d}	8.3 ± 0.4^{c}	8.1 ± 0.1^{d}	8.3 ± 0.3^{cd}	2
8.4 ± 0.3^{a}	8.4 ± 0.1^{cd}	8.3 ± 0.2^{d}	8.4 ± 0.3^{ab}	3
8.5 ± 0.6^{d}	8.5 ± 0.4^{c}	8.4 ± 0.1^{d}	8.5 ± 0.4^{c}	4
8.4 ± 0.4^{c}	8.4 ± 0.2^{d}	8.5 ± 0.4^{c}	8.4 ± 0.4^{c}	5
8.5 ± 0.5^{d}	8.5 ± 0.2^{d}	8.6 ± 0.2^{d}	8.5 ± 0.3^{d}	6
8.6 ± 0.4^{c}	8.6 ± 0.4^{d}	8.7 ± 0.4^{c}	8.3 ± 0.3^{cd}	7
8.7 ± 0.6^{c}	8.7 ± 0.5^{a}	8.9 ± 0.4^{c}	8.8 ± 0.3^{ab}	8
8.9 ± 0.1^{b}	8.9 ± 0.4^{c}	8.8 ± 0.4^{c}	8.9 ± 0.4^{c}	9

Statistical analysis:

Determining the degree and level of similarity of the studied samples in their sensory properties:

The cluster analysis test (Cluster Analysis of Variables: ASCORBIC, GLUTIN) was conducted as shown in Figure (7) to determine the degree and level of similarity of the studied samples in their sensory properties (texture, taste, smell, general acceptance). This chart showed the samples that are close in their properties in addition to the level of similarity. The most important thing that distinguishes the table are samples No. (1 and 9), as Figure No. (7) showed the similarity of the properties of samples No. (1) the market sample and samples No. (9) supported with enhancers by 68%, samples No. (3 and 4) by 85%, and samples No. (2 and 8) by 70%.

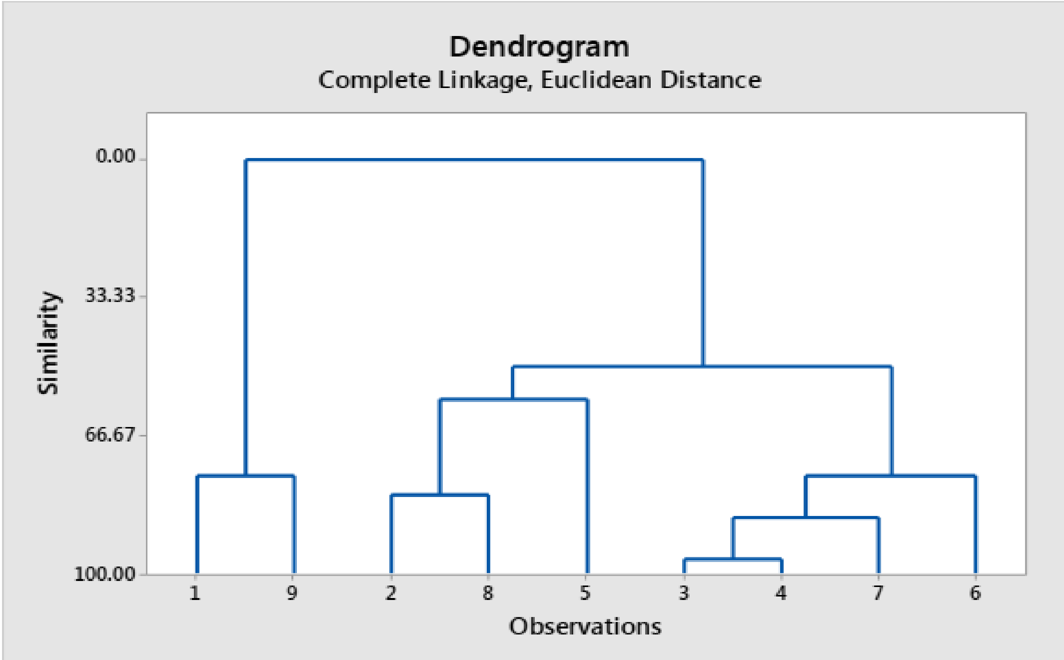

Figure (7) to determine the degree and level of similarity of the studied samples in their sensory properties.

-The results of the attached statistical analysis showed that the P-value for ascorbic acid was 0.048 and for vital gluten was 0.030, which is less than 5%. This is a positive indicator of the importance of adding improvers (ascorbic acid and gluten) to the studied samples. Table No. (13) shows the effect of the qualitative indicators of flour (dough absorbency, dough development time, stability time, weakness, and valumetric number) measured by the farinograph device on the quality characteristics of frozen dough (yeast activity, resistance and extensibility and stickiness ratio). We note from Table No. (13) The presence of a positive correlation between the percentage of water absorption and the resistance to extensibility of doughs, which reached (r=0.56), as well as a positive correlation between flour samples and dough development time according to the percentage of adding vital gluten. The most important feature of Table No. (13) is the significant correlation of the valumetric number, which reached (r=0.18) for the freezing method and (r=0.15) for the dough stickiness ratio, which is consistent with (Nikolic et al.,2013).

Table No. (13) is the significant correlation

Storage time	Freezing method	Adhesion ratio	Extensibility	Extensibility resistance	Yeast activity	
0.50	0.51	0.52	0.51	0.56	0.49	Absorbance (%)
0.33	0.31	0.37	0.38	0.39	0.31	Development time (d)
0.02	0.01	0.01	0.03	0.04	0.02	Stability time
0.49	0.50	0.54	0.55	0.60	0.50	Weakness (BU)
0.17	0.18	0.15	0.11	0.12	0.14	Valuometric number
			$p<0.05$			

- Determining the multiple correlation relationship between the studied factors: The (Partial least square regression) test was conducted to study the influential relationship between the indicators of the quantity and quality of flour protein, the percentage of gluten, the gluten index, the percentage of protein, the degree of water absorption, the dough development time, the tensile strength and the characteristics of dough quality as shown in Figure No. (8).

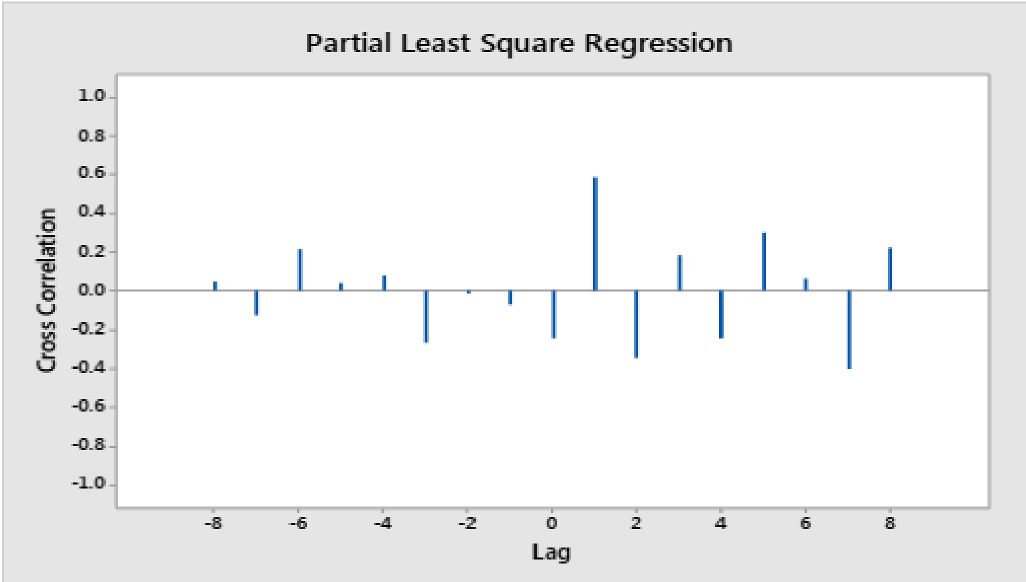

Figure (8): PLSR chart for dough quality characteristics

We note from Figure (8): The positive significant effect of the percentage of flour proteins and dough stability time, while the degree of water absorption and the valorem number had a negative significant effect.

- Determining the optimal proportions of the studied variables:

In Figure (9): The statistical analysis of the physicochemical properties of the studied dough was conducted using the (MINITAB) program, using the Advanced Design of Experiments (DOE) program, type Factorial Designs) and the (Response Optimization) test to determine the optimal proportions of the studied variables. The test results showed the positive effect of the improvers on the physicochemical properties of the studied samples through the low values of P-Value, as it reached (0.048) for ascorbic acid and (0.030) for vital gluten, which is a positive indicator of the importance of adding the studied improvers.

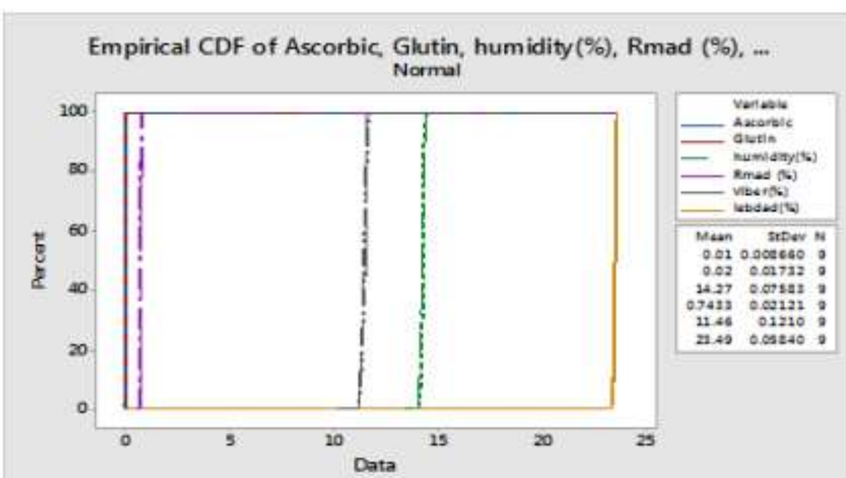

Figure (9): Optimal levels chart showing the effect of improvers on the physicochemical properties of the studied samples

Results and discussion:

1. The results of evaluating the physicochemical and rheological properties of frozen dough ،whether by the slow or rapid method ،showed a deterioration in these properties during the frozen storage process at a temperature of -18 ºC for (30, 60, 90 and 120 days), but the final quality of the frozen product was affected by the freezing rate.

2.Adding improvers led to a significant increase in fermentation strength ،while a significant negative effect of storage time on yeast activity was observed, as fermentation strength values decreased for all samples in both freezing methods with increasing frozen storage time.

3. The maximum average resistance to expansion of frozen dough decreased after 120 days of frozen storage. The extensibility values decreased with the continuation of the frozen storage process. The adhesion values of dough frozen by the slow and rapid methods also increased.

4. The results showed that adding ascorbic acid improves the ability of the dough to retain gases by strengthening the gluten network ،increasing the volume of the dough and reducing the fermentation period ،making it have finer pores and a homogeneous core ،reducing the phenomenon of dormancy and extending the shelf life of the dough.

5. The results of the statistical analysis showed that the optimal ratios for strengthening the dough are 200 ppm ascorbic acid and 4% vital gluten ،which gave a positive effect on the quality characteristics of the dough.

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