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Scientific Research

Investigating the effect of storage time on the rheological characteristics of processed cheese produced from egg white, corn oil and soy protein

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ABSTRACT

In this research, the effect of storage time on the characteristics of extensibility and consistency of processed cheese samples produced from egg white, corn oil and soy protein was investigated. First, in order to optimize the formulation of processed cheese from the central composite statistical design at three levels for three independent variables including soy isolate protein (0, 7.5, 15% W/V), corn oil (0, 8, 16% by V/V).) and egg white (0, 3, 6% V/V) were used. On the other hand, the optimal formulation of processed cheese was obtained with the objective of maximum scores of the two characteristics of extensibility and texture continuity, using the utility function method. Finally, the effect of storage in three time periods (0, 1, and 2 months) on the two characteristics of extensibility and consistency of the optimized sample texture was investigated by relying on physical changes. According to the obtained results, the effect of time on the extensibility characteristic showed that with the passage of time, the extensibility of processed cheese samples increased significantly in the negative direction. According to the results, the interaction effect of egg white/time and corn oil/time; It showed that with the passage of time (in the presence and absence of egg white and corn oil), the expandability of the produced samples increased significantly in the negative direction. Also, the effect of time on consistency characteristics showed that with the passage of time, the consistency of processed cheese samples decreased significantly. The results of this study are favorable for the development of processed cheese and dairy products containing egg white, corn oil and soy protein.

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1- Introduction

In recent years, with the increase in public awareness of the dangers of saturated fats, cholesterol and high calories, the demand for low-fat foods has increased.But dairy products such as low-fat cheese needed to improve the texture and use suitable substitutes due to their hard texture[1]. On the other hand, excessive use ofEmulsifying salts are also harmful for health, although they play an important role in creating uniform and desirable texture. Therefore, nowadays, in order to reduce the use of these compounds, vegetable and animal proteins with emulsifying properties are used as a substitute for emulsifying salts.[2].
Processed cheese is a dairy product that is not made directly from milk, so that the main composition of processed cheese is a variety of natural cheeses.[3]. Processed cheese is produced by mixing different types of natural cheese with different ripening degrees along with emulsifying salts and heating and cutting. The heating process is done by direct and indirect injection of steam in the baking machine at a temperature of 75-85 degrees Celsius for 1-5 minutes. The cutting action is carried out at a uniform speed under partial vacuum or without vacuum until the compact mass is reached[4]. Cheese production is the process of converting the insoluble protein in all types of rancid and acidic clots into hydrated and spreadable protein[5], so that the hydrated protein binds the free water and emulsifies the fat released from the cheese during processing and finally creates processed cheese with stable physicochemical properties. These changes in the protein structure are made with the help of emulsifier salts which are added at the rate of 1.5-3% at the beginning or before the thermal process. These salts are compounds containing phosphates and citrates, which lead to the destruction of the calcium balance in the matrix and the creation of a new balance between dissolved calcium and protein-bound calcium.[6].

Eggs are one of the most important sources of high quality protein; Also, egg protein has an antioxidant such as fosvitin, which contains a large amount of phosphorein, ovotransferrin, and canFe^{3+} It can be chelated and can prevent the oxidation of lipids by bonding to metals[7]. Also, there are more than 40 types of proteins in egg white, so that the main proteins involved in its functional characteristics include ovalbumin (54%), conalbumin (12%), ovumocoid (11%) and lysosome (3.5%). . Egg white protein is a food compound with multiple functional properties such as foaming, emulsifying, gelling and adhesion. Therefore, it is used in many food products such as bakery products, cakes, etc. as a combination with functional properties.[8]. Eggs and their whites, which are not only used alone, but also increase the nutritional value of the formulation and are therefore widely used in nutrition, usually as additives for emulsifying, moisturizing, pasting properties. Its coloring, flavoring and thickening agent are used in the processing of many foods, especially cheese. The use of egg white is also considered as an important additive in terms of baking quality due to its kneading, thickening, binding and constituent properties of the ingredients.[9].

Corn is known as one of the types of cereals with the highest amount of oil in its large sprout. Originally, corn itself is not known as an oilseed because it contains 3-5% lipids in the seed. The germ makes up about 9-11% of the weight of the seed and contains 80% of lipids in the whole seed. Most commercial corn oil is extracted from the germ and is known as corn germ oil[10]. One of the special nutritional values of corn oil is the presence of significant amounts of tocopherols and tocotrienols, which act as

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antioxidants and increase the oxidative stability of the oil. In addition, corn oil contains high levels of unsaturated fatty acids, especially linoleic acid and oleic acid.[11]. Due to the inherent stability of corn oil, this oil has a long shelf life and is resistant to changing the conditions of the reverse process. Refined corn oil is used in frying, salad and as a raw material in the process of refining fats. Also, this oil has more points among other vegetable oils due to its excellent sensory and nutritional properties and good performance in food processing. Corn oil is slightly yellowish, with a mild and distinct smell and taste[10].

Soy protein is one of the most important commercial food proteins, available, with high nutritional value, suitable functional properties, health effects such as improving liver function, reducing the risk of cancer, strengthening memory and intelligence, lowering blood pressure, and reducing bad blood cholesterol. did[12]. In addition to protein and oil, the beneficial physiological effects of compounds such as daisin and isoflavone in soybeans have also attracted a lot of attention.[13]. Another advantage of soy protein is that it has excellent processing capabilities such as gelling, emulsifying and water and oil holding capacity. Soybeans contain approximately 40% protein and 20% oil on an average dry matter basis. By removing the oil at lower temperatures, soy protein isolate is obtained and is widely used in the food industry[14]. Soy extractable aqueous complete proteins can be stored as globulin and whey fractions by acidification topH 5/4-8/4 separated. The acid-precipitable fraction contains the main storage proteins of soy. The remaining part contains minor globuling-conglycinin And there are relatively large amounts of contaminating proteins, including whey protein, which constitutes 9-15.3% of soy protein.[15]. In the end, the aim of this research is to evaluate the effect of storage time on the properties of extensibility and consistency of processed cheese produced from egg white, corn oil and soy protein in order to achieve the right combination to produce a healthy product with high quality and shelf life.

2- Materials and methods

1-2- Materials

In order to perform the tests required for this research,Feta cheese with specifications (pH: 4.99, acidity: 1.3%, moisture: 62.2%, fat: 15%, protein: 13.18, salt: 2.85%), corn oil and egg white were obtained from sales centers in Sanandaj city. Soy protein isolate with 85%, emulsifier salt, hydroxide 0.1 normal, phenolphthalein, citric acid, sulfuric acid, amyl alcohol, potassium sulfate, copper sulfate, sodium 50%, boric acid, phenol red, hydrochloric acid 0.1 normal , sodium citrate, culture media (Kant agar plate– Sabrodextrose agarAnd MRS – Agar) and emulsifier salt, all from the companyMerck Made in Germany.

2-2- Preparation of processed cheese

First, for the production of processed cheese, the percentage of dry matter and fat of base cheese (feta cheese) was calculated. Then, a certain amount of cheese based on the weight and based on the amount of dry matter without fat, certain percentages of egg white (0, 3 and 6%) and corn oil (0, 8 and 16%) were added to it and at a temperature close to The medium was mixed for 1-2 hours until the dough was completely soft and homogeneous. Then, the emulsifier salt along with certain percentages of soy protein isolate (0, 7.5 and 15%) were mixed well with other ingredients and entered into the cooking machine.[16]. The resulting mixture is stirred in the baking machine without creating shear stress until the temperature of the mixture reaches 70-75 degrees Celsius and in the continuation of the mixing process with shear stress (speedRPM 3000) at a temperature of 85 degrees Celsius for 5

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minutes; After the mentioned period of time, emptying and packing in 150 gram containers was done hot, and cooling was done immediately in the cold room for 3-4 hours to a temperature of 5-10 degrees Celsius.[17].

2-3- The effect of time and formulation variables on propertiesextensibility[1] Optimal processed cheese samples

In order to evaluate the effect of time on the extensibility of cheese samples, the parameters of hardness, stickiness, the work required to overcome stickiness (expandability) and the work required for cutting using a texture testerTA.XTplus Made in England was analyzed; For this purpose, processed cheese was placed in the funnel of the device and the conical probe entered the funnel at a speed of 3 mm per second and after traveling a distance of 23 mm, the force-time curve was drawn by the software.[18].

4-2- The effect of time and formulation variables on continuity properties[2] Optimal processed cheese samples

in order toCheckThe effect of time on the rateContinuity of processed cheese samples produced by rheometer deviceAnton Paar Physica(Model300 MCR , made in Austria) consisting of two parallel plates with a diameter of 25 mm and the distance between the plates according to the thickness of the samples was used. In the first stage, by doing the testStrain relief with a fixed frequency of 10 Hz in the range The strain is between 0.1-100 percent of the viscoelastic range A line was determined and in the second step, the frequency scan change test was performed at a strain of 0.1% and a frequency of 0.01-100. took Examples of depthcm Cut 1 of each cheese and cook for 4 The clock was kept at room temperature. Eventually parameters such as complex viscosity, storage modulus, viscous modulus andchanges rate(TD) tan d It was reported[17].

5-2- Statistical analysis

In this research, firstly, in order to optimize the formulation of processed cheese from the central composite statistical design in three levels for three independent variables including soy protein isolate (0, 7.5, 15%), corn oil (0, 8, 16%) and egg white. Egg (0, 3, 6%) was used. On the other hand, the optimal formulation of processed cheese was obtained with the objective of maximum scores of the two characteristics of extensibility and texture continuity, using the utility function method. Finally, the effect of storage in three time periods of three months (0, 1 and 2 months) on the two characteristics of the expansion and continuity of the optimized sample texture and physical changes using the softwareSPSS Statistics 27.0.1 was investigated.

[1]-Spreadability

[2]- Conjunction

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3. Results and Discussion

1-3- The effect of time and formulation variables on the expandability of processed cheese samples

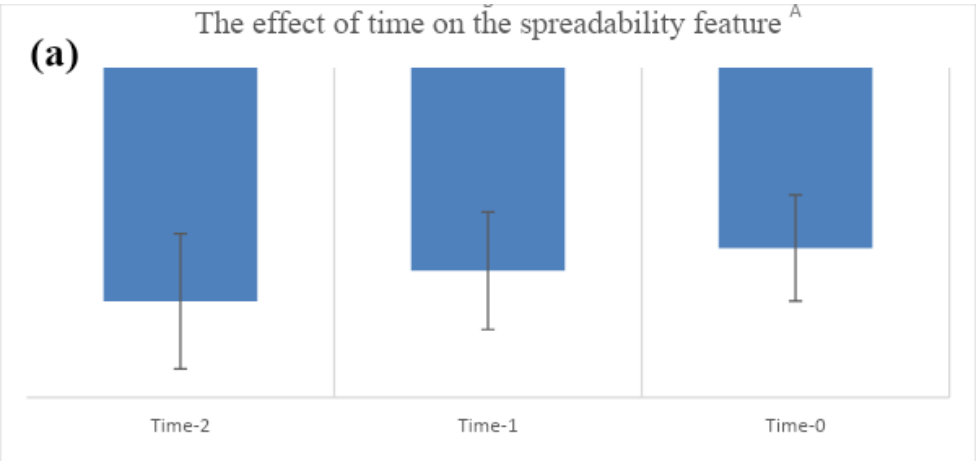
Based on the results of ANOVA analysis(Table 1) and charts presented in(Fig 1)، The effect of time on the extensibility characteristic showed that with the passage of time, the extensibility of processed cheese samples increased significantly in the negative direction.($P<0.05$) (Fig 1-a). The interaction effect of egg white/soy protein isolate decreased in the negative direction if soy protein isolate was used(Fig 1-b) ؛Also, in samples containing egg white, the expandability of cheese samples compared to samples without egg white showed an increase in the negative direction. In other words, according to all the results, the sample containing egg white and without soy protein isolate had the highest amount of expansion in the negative direction. On the other hand, in the investigation of the interaction effect of egg white/corn oil, it increased in a negative direction if corn oil was used(Fig 1-c); And in the samples containing egg white compared to the samples without it, a significant increase in the negative direction was shown; In total, the sample containing corn oil and egg white showed the highest expandability in the negative direction among the examined samples. Therefore, according to the results, it can be said thatEgg white protein by creating a network and a strong protein structureDue to having functional properties such as emulsifying and creating gel and adhesionIt leads to increased scalability[8،19]، Also, according to the results of the interaction effect of egg white/time and corn oil/time(Fig 1- d/e)؛ It showed that with the passage of time (in the presence and absence of egg white and corn oil), the expandability of the production samples increased significantly in the negative direction.($P<0.05$) And this increase was more in samples containing egg white and corn oil; So that the highest amount of expandability was observed in the presence of egg white and corn oil in the second month. Also, the interaction effect of soy protein isolate/time(Fig 1-f) ؛It also showed that with the passage of storage time, the extensibility of the fabric of the production samples increased($P<0.05$) And this increase was more in the samples without soy protein isolate, in the results according to the graphs, the most expandable property was shown in the sample without soy protein isolate in the second month of storage.

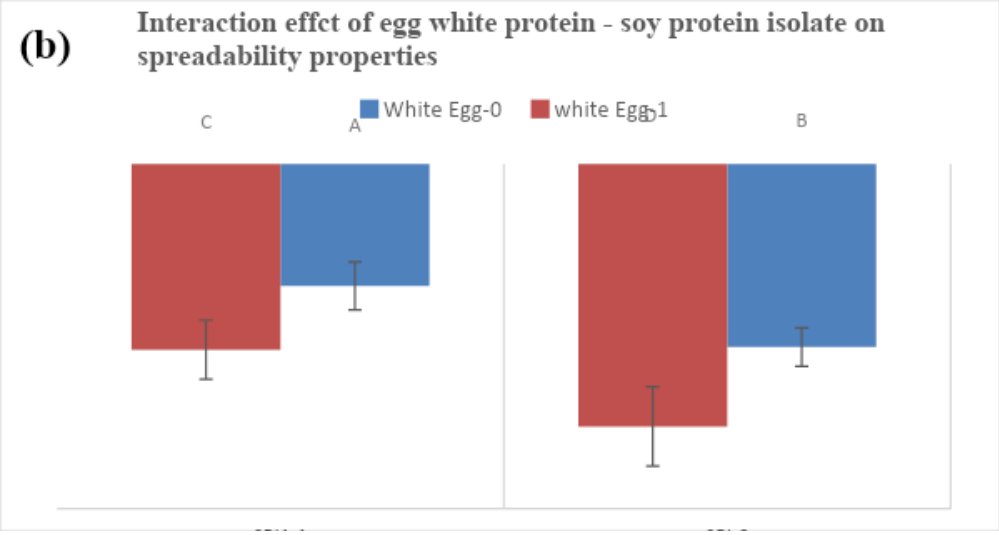
Table 1: The results of analysis of the variance of the spreadability of processed cheese

average of squares	Degrees of freedom	Sources Change
**1243.92	1	egg white
**1152.72	1	Soy protein isolate
**292.3	1	corn oil
**385.8	2	Time
**15.01	1	Egg white / soy protein isolate
**8.49	1	Egg white/corn oil
**31.68	2	Egg white / time
0.22 ^{ns}	1	Soy Protein Isolate / Corn Oil
**4.49	2	Soy protein isolate / Time
**1.35	2	Corn oil/time
0.17 ^{ns}	1	Egg white / soy protein isolate / corn oil
**23.67	2	Egg white / soy protein isolate / time
**9.36	2	Egg whites/corn oil/time

**6.62	2	Soy protein isolate/corn oil/time
**4.46	2	Egg white/soy protein isolate/corn oil/time
99/89	-	R^2
3.66	48	Error

*:p≤0.05, **:p<0.01, :ns(non-significant) p≥0.05





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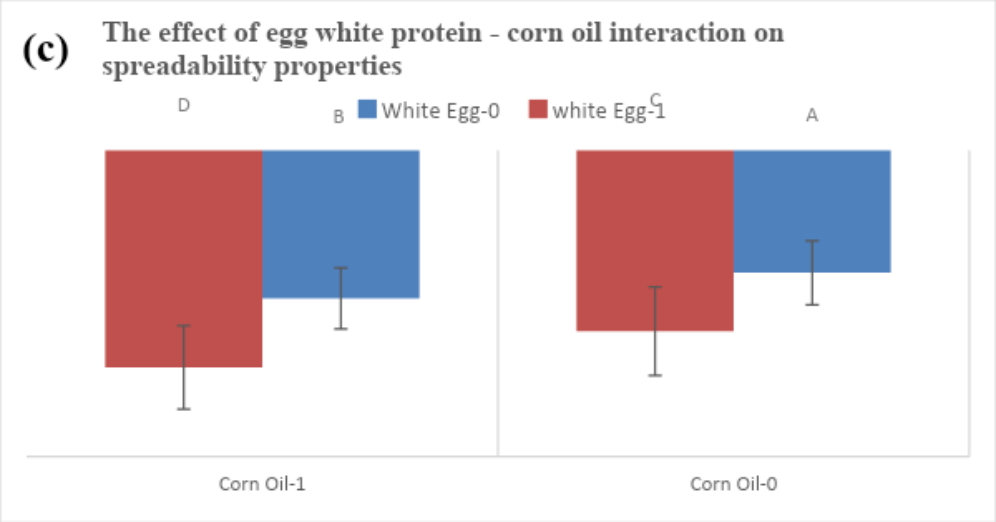

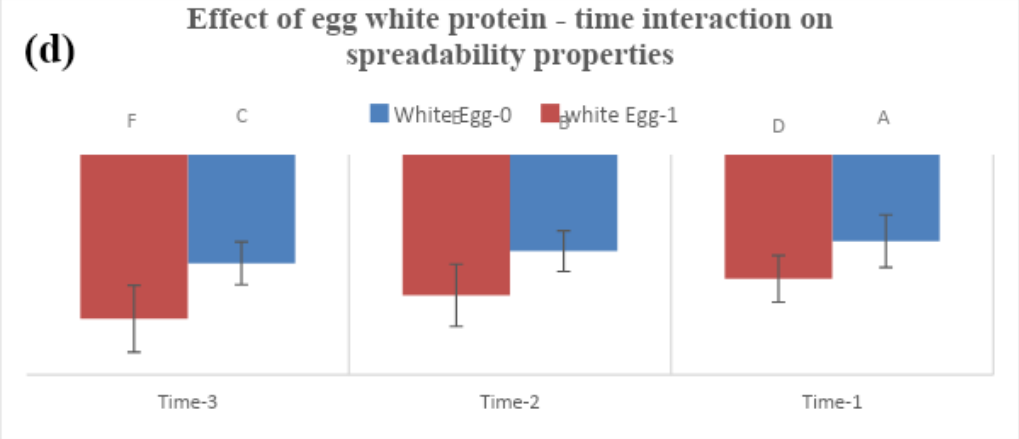

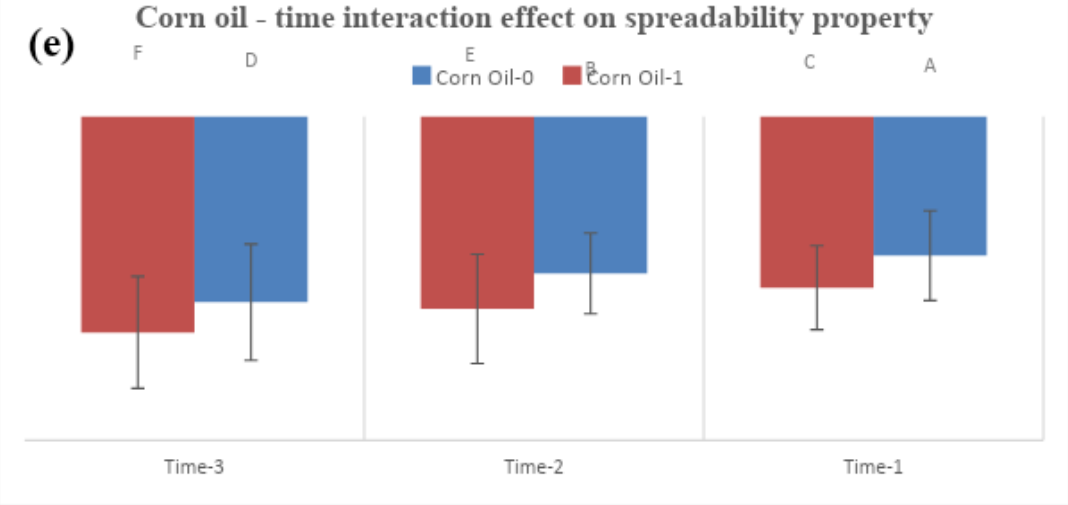

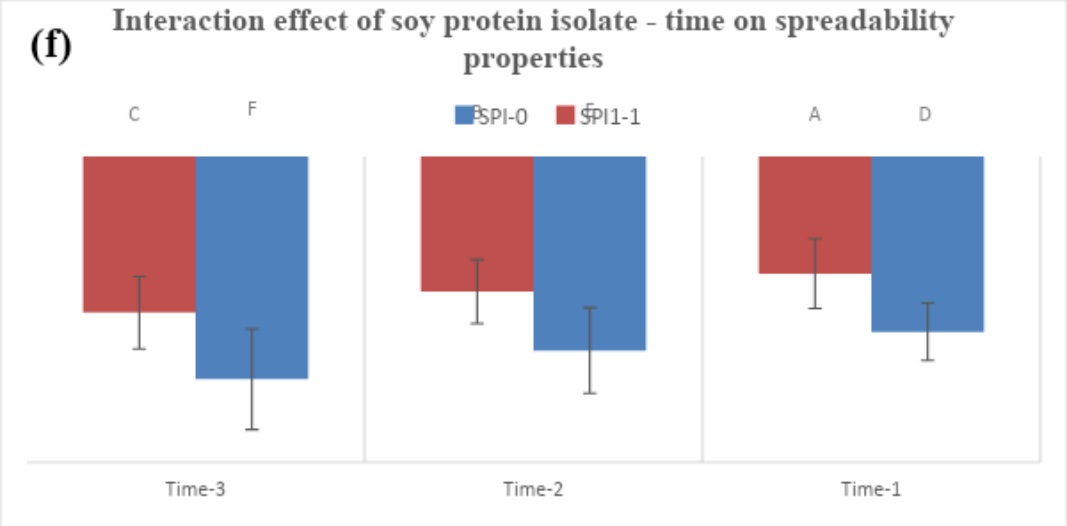

Fig 1: (a, b, c, d, e, f) Diagrams of the effect of time and formulation variables on the spreadability characteristics of processed cheese

2-3- The effect of time and formulation variables on the cohesive properties of processed cheese samples

Based on the results of ANOVA analysis(Table 2) and the resulting graphs in Fig(Fig 2), the effect of time on consistency characteristics showed that with the passage of time, the consistency of processed cheese samples decreased significantly($P<0.05$) (Fig 2-a). In the samples without egg whites, the consistency of the produced cheese samples was significantly reduced by adding soy protein isolate; But in the samples containing egg white, the cohesion of the samples increased by adding soy protein isolate. Also, in the examination of egg-free/egg-containing/soybean isolated protein samples, the consistency was less in the egg-containing samples, and on the other hand, in the egg-free/egg-containing/soybean isolated protein samples, in the sample containing The consistency of the eggs of processed cheese samples was higher(Fig 2-b). Therefore, according to the obtained results, it can be stated that soy protein isolateIt prevents the formation of long strands due to the hydrophobic interaction of the base cheese proteins with themselves, and by creating empty spaces, it leads to a decrease in cohesion.[20]; While egg white has been able to increase cohesion due to its properties such as high heat resistance, water absorption, creating hydrophobic interactions with basic cheese protein and soy protein isolate, and creating a dense and elastic gel network.[21]. In the investigation of the interaction effect of soy protein isolate/corn oil, in the samples without soy protein isolate, with the addition of corn oil, the consistency of the produced cheese samples decreased significantly; However, no significant difference was observed in samples containing soy protein isolate. Also, in the examination of samples without soy protein isolate / containing soy protein isolate / without corn oil, the consistency was less in samples containing soy protein isolate, and on the other hand, in the analysis of samples without soy protein isolate / containing soy protein isolate / containing corn oil, In the sample containing soy protein isolate, the consistency of the produced processed cheese samples was also lower(Fig 2-c) [22]. Also, according to the results of the interaction effect of soy protein isolate/time and corn oil/time(Fig 2-e/f) ،showed that with the passage of time (in the presence and absence of soy protein

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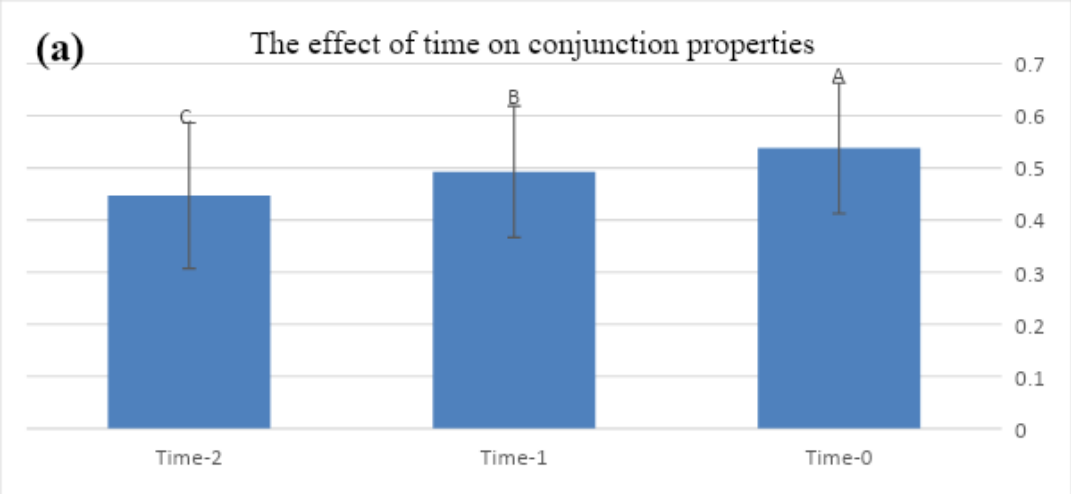
isolate and corn oil), the consistency of the production samples decreased significantly.(P<0.05) And this decrease was more in the samples containing soybean protein isolate and corn oil; Thus, the lowest degree of consistency characteristic was observed in the interaction effect of soy protein isolate/time and corn oil/time in the second month and in the samples containing soy protein isolate and corn oil. Also the egg white/time interaction(Fig 2-d) ؛It also showed that with the passage of time of storage, the consistency characteristic of produced cheese samples decreased(P<0.05)؛ On the other hand, the examined samples (with/without egg white) did not show any significant difference in the second month of storage.

Table 2: The results of the analysis of the variance of the conjunction characteristic of processed cheese

average of squares	Degrees of freedom	Sources Change
**0.007	1	egg white
**0.182	1	Soy protein isolate
**0.029	1	corn oil
**0.099	2	Time
**0.366	1	Egg white / soy protein isolate
**0.286	1	Egg white/corn oil
**0.003	2	Egg white / time
**0.277	1	Soy Protein Isolate / Corn Oil
0.001 ^{ns}	2	Soy protein isolate / Time
**0.004	2	Corn oil/time
**0.034	1	Egg white / soy protein isolate / corn oil
0.001 ^{ns}	2	Egg white / soy protein isolate / time
**0.003	1	Egg whites/corn oil/time
**0.008	2	Soy protein isolate/corn oil/time
*0.002	1	Egg white/soy protein isolate/corn oil/time
98.78	-	R^2
0.015	48	Error

*:p≤0.05, **:p<0.01, :ns(non-significant) p≥0.05



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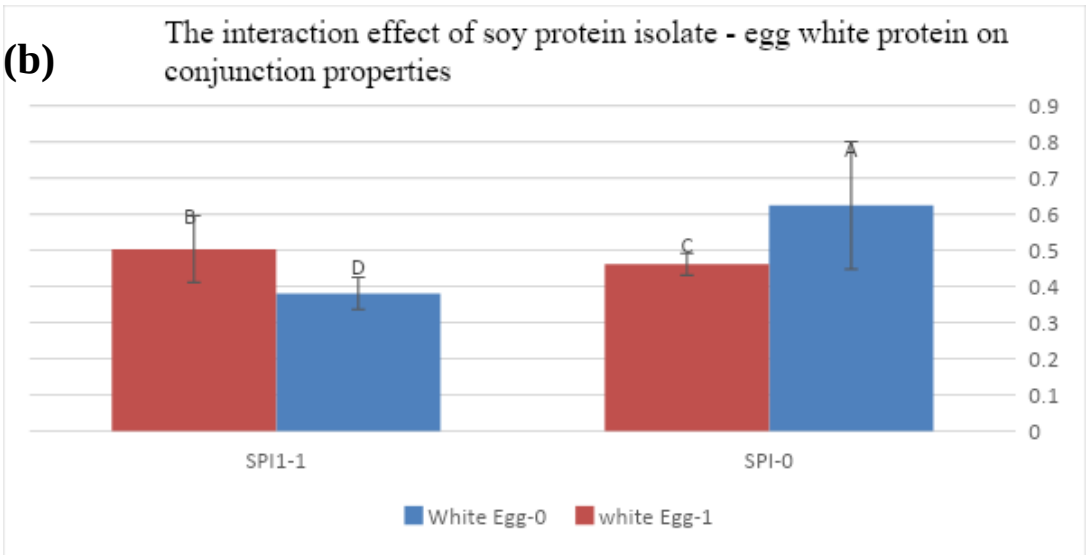

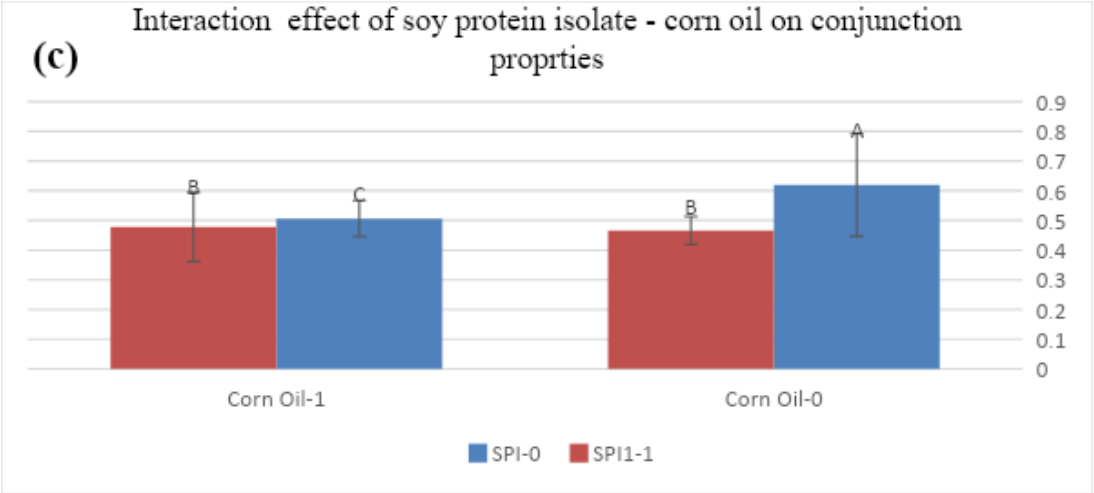

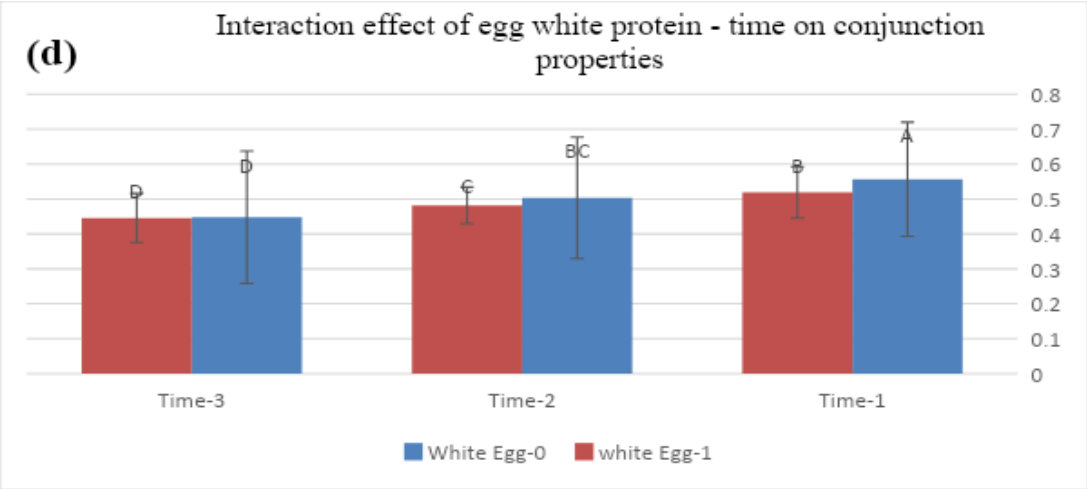

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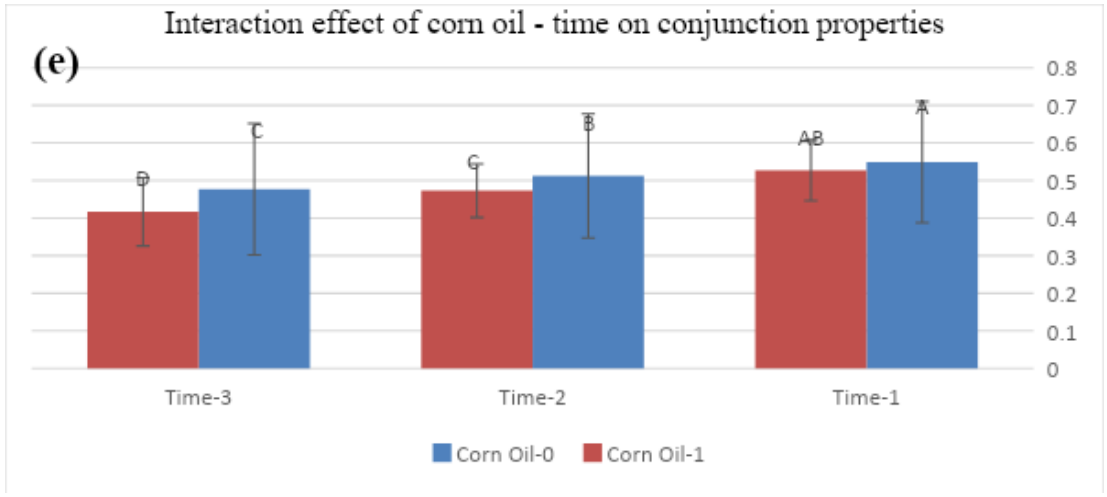

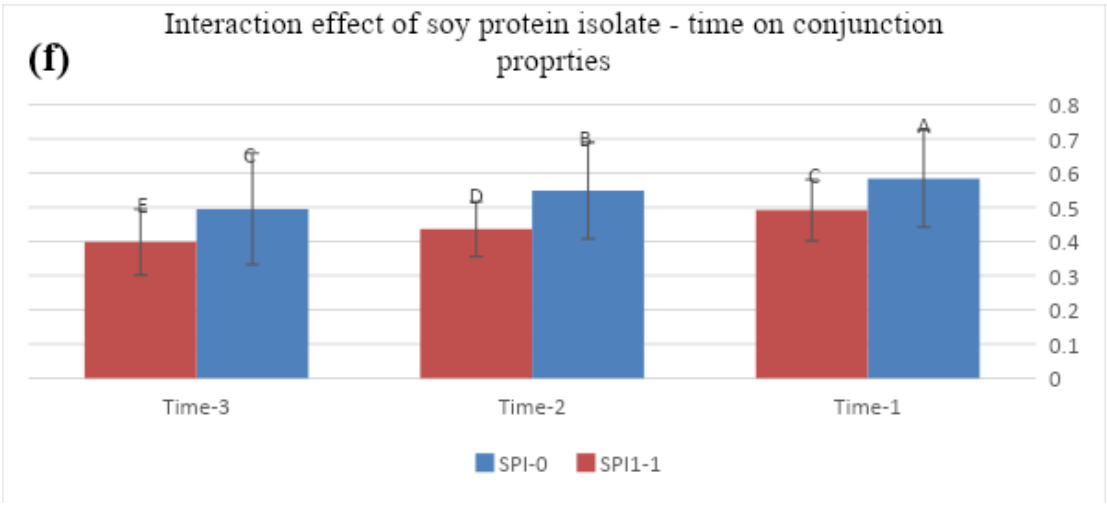

Fig 2: (a, b, c, d, e, f) Diagrams of the effect of time and formulation variables on the conjunction properties of processed cheese

4 - Conclusion

According to the obtained results,The effect of time on the extensibility characteristic showed that with the passage of time, the extensibility of processed cheese samples increased significantly in the negative direction. According to the results of the interaction effect of egg white/time and corn oil/time; It showed that with the passage of time (in the presence and absence of egg white and corn oil), the expandability of the produced samples increased significantly in the negative direction. And this increase was more in samples containing egg white and corn oil; So that the highest amount of expandability was observed in the presence of egg white and corn oil in the second month. Also, the interaction effect of isolated soybean protein/time; also showed that with the passage of storage time, the tissue extensibility of the production samples increased and this increase was more in the samples without soy protein isolate. The effect of time on consistency characteristics showed that with the passage of time, the consistency of processed cheese

samples decreased significantly. Also, according to the obtained results, the interaction effect of soy protein isolate/time and corn oil/time on the consistency property showed that with the passage of time (in the presence and absence of soy protein isolate and corn oil), the consistency property of the production samples decreased significantly. It was found that this decrease was more in the samples containing soy protein isolate and corn oil; Thus, the lowest level of continuity characteristic was observed in the interaction effect of soy protein isolate/time and corn oil/time in the second month and in the samples containing soy protein isolate and corn oil. Also, the interaction of egg white/time; It also showed that with the passage of time of storage, the consistency characteristic of produced cheese samples decreased؛ On the other hand, the examined samples (with/without egg white) did not show any significant difference in the second month of storage. The results of this study for the development of processed cheese production Useful dairy products containing egg white, corn oil and soy protein It is desirable.

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بررسی تأثیر زمان ماندگاری بر روی ویژگی های رئولوژیکی پنیر پروسس تولیدی از سفیده تخم مرغ، روغن ذرت و پروتئین سویا

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چکیده

در این پژوهش به بررسی تأثیر زمان ماندگاری بر روی ویژگی های گسترش پذیری و پیوستگی نمـونه های پنیر پروسس تولیدی از سفیده تخم مرغ، روغن ذرت و پروتئین سویا پرداخته شد. ابتدا به منظور بهینه سازی فرمولاسیون پنیر پروسس از طرح آماری مرکب مرکزی در سه سطح برای سه متغیر مستقل شامل پروتئین ایزوله سویا (۰، ۷/۵، ۱۵٪ وزنی/ حجمی)، روغن ذرت (۰، ۸، ۱۶٪حجمی/ حجمی) و سفیده تخم مرغ (۰، ۳، ۶ ٪ حجمی/ حجمی) استفاده شـد. از طرفی فرمولاسیون بهینه پنیر پروسس تولیدی با هدف حداکثر امتیازات دو ویژگی گسترش پذیری و پیوستگی بافت، با روش تابع مطلوبیت بدست آمد. در نهایت اثر انبارداری در سه بازه زمانی (۰، ۱ و ۲ ماه) بر دو ویژگی گسترش پذیری و پیوستگی بافت نمونه بهینه شده با تکیه بر تغییرات فیزیکی مورد بررسی قرار گرفت. با توجه به نتایج به دست آمده، اثر زمان بر ویژگی گسترش پذیری نشان داد که با گذشت زمان گسترش پذیری بافت نمونه‌های پنیر پروسس تولیدی در جهت منفی به طور معناداری افزایش یافت. مطابق نتایج حاصل، اثر متقابل سفیده تخم مرغ/ زمان و روغن ذرت/ زمان؛ بر ویژگی گسترش پذیری نشان داد که با گذشت مدت زمان تعیین شده (در حضور و عدم حضور سفیده تخم مرغ و روغن ذرت) ویژگی گسترش پذیری نمونه های تولیدی در جهت منفی به طور معناداری افزایش یافت. همچنین اثر زمان بر ویژگی پیوستگی نشان داد که با گذشت زمان پیوستگی نمونه‌های پنیر پروسس تولیدی به طور معناداری کاهش یافت. نتایج این مطالعه برای توسعه تولید پنیر پروسس و محصولات لبنی فراسودمند حاوی سفیده تخم مرغ، روغن ذرت و پروتئین سویا مطلوب است.