JOURNAL OF CRITICAL REVIEWS

ISSN- 2394-5125 VOL 8, ISSUE 01, 2021

Effect of Flint and Floury Corn Flour Mixtures on the Colorimetric and Organoleptic Properties of the Enzymatically Hydrolysed Glucose Syrup

Fereshteh Fatourehchi
Zar Macaron University of Applied Sciences and Technology
fatoorechi.f@gmail.com

Flora Farrokhi[1]
Department of Food Science and Technology,
Science and Research Branch, Islamic Azad University,
Tehran, Iran
flora.farrokhi@srbiau.ac.ir

Orang Eyvazzadeh
Department of Food Science and Technology,
Varamin Branch, Islamic Azad University
orang_eyvazzadeh@yahoo.com

Ali Bahadori
R&D Department, Gandomkob Company
ali.bahadori66@yahoo.com

Amin Sayed Yaghoubi
R&D Department, Zar Macaron Company
amin.yaghoubi@yahoo.com

Abstract

Floury (soft) corn (*Zea mays var. amyalcea)* is mainly used in glucose syrup industry, but most of the imported corn is flint or hard corn (*Zea mays var. indurate*). Considering the necessity and importance of using soft and hard corn flour mixture in the production glucose and fructose syrups and the impact of corn flour on the produced syrups properties, in this study, by replacing hard corn flour with soft corn flour (with percentages of 0%, 30%, 50% and 70%), glucose syrup was produced and the effect of corn flour substitution ratios on the sensory properties and colorimetric parameters of glucose syrup obtained from these flour mixtures was investigated. The results showed that increasing the ratio of hard corn flour up to 70% substitution, significantly affected the colorimetric and organoleptic properties of the produced glucose syrup including color parameters, flavor and taste, aroma, visual color, appearance and overall acceptance and reduced them ($p<0.05$). According to the obtained results, it is possible to use hard corn in different replacement amounts less than 70% in terms of appearance and organoleptic characteristics in the production of glucose syrup. Also, glucose syrup obtained from soft corn flour, which has been replaced with less than 50% hard corn flour has the ability to become fructose syrup as a substitute for sugar in the food industry in terms of appearance and organoleptic characteristics.

Keywords: Colorimetric Parameter, Enzymatic Hydrolysis, Flint (hard) corn, Floury (soft) corn, Glucose syrup, Organoleptic Properties.

Introduction

Glucose syrups can be considered as the most important multipurpose sugar additives. Glucose syrup is a clear liquid containing a range of carbohydrates (from dextrose to dextrins) that are obtained through two processes of starch hydrolysis followed by hydrolyzed refining from various source [1]. Due to the advantages of this syrup over other sweeteners, it has been considered by many industries and consumers. This syrup is one of the natural sweeteners and provides the sweetness equivalent to the sweetness of sugar [2]. Glucose syrup is used in the food industry not only because of its sweetening power and nutritional value, but also because of its functional properties (moisture stabilization, softening ability, helping to form tissue, preventing the crystallization of sucrose and helping to form crust in baking products) [3,4]. In general, the properties of glucose syrups can be summarized as follows: a

1-Corresponding Author

syrup with low DE causes volume, adhesion, foam stability, prevents sucrose crystallization and viscosity. On the other hand, a syrup with high DE can cause brown color, increase fermentation, increase flavor, decrease freezing point, increase osmotic pressure and increase sweetness in the produc [1,4]. Glucose syrup is used in food to soften the texture, increase the volume, prevent the crystallization of sugar and enhance the flavor. The low freezing point of liquid glucose makes it an ideal ingredient for use in ice cream, making the texture softer and more stable. It prevents the crystallization of sugars and is used in the production of candies, turmeric, jams, jellies and caramels. In bread production, liquid glucose is used as a carbohydrate source for yeast and promotes better fermentation of the dough, which in turn helps to produce high quality bread. In the production of biscuits, cakes and sweets are also used as sweeteners, crushers and to create the desired brown color in these products. Liquid glucose is also used in the preparation of non-alcoholic beverages to control sweets, beverages, improve aroma, taste and mouthfeel [1,3,5]. Starch, as the most abundant stored carbohydrate in plants, is the only raw material needed for the industrial and mass production of various types of glucose syrups. Hydrolyzed products from different starch sources are identical in chemical, physical and organoleptic (sensory) properties. As a result, starch hydrolysis products are produced from a wide range of raw materials around the world [6]. The most important sources of starch in the world are corn, wheat, rice, potatoes, tapioca and sago. The type of starch source and its purity affect the production process of glucose syrups. The very high efficiency of corn production has made this plant source as the main primary source for starch extraction and production of glucose syrups [2,7]. Hydrolysis of starch is done through three methods: acidic, acidic-enzymatic and enzymatic-enzymatic. Due to the disadvantages of using acid hydrolysis in the production of glucose syrups, the use of enzymatic methods has been considered the dominant process due to better control of process conditions and the resulting products. By enzymatic hydrolysis of starch, a syrup with DE 95 or more can be prepared [3,8].

Among starch sources, corn starch is one of the best sources of glucose syrup. Hard corn is called *Zea mays var. indurate*. The entire endosperm of this type of corn, which is in the center of the grain, is covered with a hard layer of endosperm. The ripe grains of this type of corn are round, smooth and amber. Their growth period is 80 to 100 days. The resulting ears are narrow and have about 8 rows of grains [4]. 15% of world corn production is of this type. This corn often has a thick, hard, glassy layer of endosperm. This layer forms the bulk of the grain and the grain has a smooth and shiny surface. Flour corn (soft) is called *Zea mays var. amyalcea.* Most of the endosperm of this type of corn is starch [9]. Only a thin layer of hard endosperm contains this starch. Its seeds do not have sunken teeth, unlike the type of horse teeth. Since the endosperm of maize flour is almost entirely composed of very soft starch, the grains tend to shrink evenly as they dry, so they do not become serrated or have very low serrations. This corn is used to decorate food only because it is found in different colors. Also, because its endosperm is soft, it can be used in the same way without crushing and crushing it in animal feed. 10 to 12% of world corn production is of this type [4,10]. Corn from the MILING WET method is used to produce glucose syrup, in which the starch is separated from the corn set and mechanically separated into parts. Includes: starch, shell, protein and oil. The resulting starch is then converted to glucose and by enzymatic methods, glucose is converted to fructose and corn syrup is obtained with 42% fructose [3,7].

A researcher [5] investigated the possibility of using alpha-amylase enzyme in the production of maltodextrin using corn flour. In this study, the amount of equivalence dextrose in terms of dry matter was affected by three concentrations of enzyme (0.2, 0.25 and 0.3 ml per kg of starch) and at three different temperatures (60, 65,70 °C) in Hydrolysis time and constant pH 6 were evaluated. The results showed that the amount of dextrose in the product under the influence of different concentrations of enzyme (at the same temperature and time of hydrolysis) were significantly different from each other. Another researcher [11] by producing glucose syrup on a laboratory scale using enzymatic hydrolysis of starch obtained from corn, millet and sorghum and comparing them, concluded that sorghum starch and yellow corn flour have good potential as Substrate for glucose syrup production. A study [12] compared the potential of apricot, cassava, potato starch with corn flour to produce high fructose syrup. The results showed that the suppliers of tuber starch are an alternative to corn flour in the production of high glucose and fructose syrup. Also a researcher [13] conducted an experiment to investigate the effective parameters for the industrial production of glucose syrup. In this experiment, the effect of different amounts of industrial amylase enzyme used to make glucose syrup from starch was investigated to determine the optimal amount of enzyme to add, depending on the turbidity, color and wavelength of the final starch solution to the syrup. Glucose is called, get. The results showed that optimal values with a volume of 100 ml of starch solution can be inferred in the added volume of 10 cc of amylase enzyme. The results also showed that at times higher than 1 hour, time did not have a significant effect on the turbidity and color of the production solution.

At the same time, depending on the type of starch as well as the type of process by which this starch is mixed with water and other substances, the syrup becomes a superior or clear glucose syrup. Premium syrup is a high quality glucose syrup and its color is clear [14]. Low-quality glucose syrups are similar to honey and have a light brown color. Therefore, the color of glucose is a sign of the quality of this product that many factors are involved in the quality and specialness of this product. The temperature in the tube may be high, the acid may not be used enough, or it may be overused [8,11]. Also, after enzymatic conversion, the syrup obtained from corn flour contains

ISSN- 2394-5125 VOL 8, ISSUE 01, 2021

insoluble components in the amount of 0.1-2 microns. These components include gelatinized starch or amylose-lipid complexes that adversely affect the filtration properties [9,12]. In the production of glucose syrup from starch, browning reactions occur which lead to the production of undesirable color in the syrup. Purification methods include the use of coagulants, centrifugation, filtration of vacuum cylinders by means of filtration and ultrafiltration to remove insoluble materials of syrup and the use of activated carbon, ion exchangers and coloring resins are used to separate soluble materials of syrup [6,7,9].

According to the above explanations, although in the glucose syrup industry soft corn starch is mainly used, but most of the imported corn is hard corn and hard corn is available all year round, so the syrup producer has to use both types of corn. Considering the necessity and importance of using soft and hard corn flour mixture in the production glucose and fructose syrups and the impact of corn flour on the produced syrups properties, in this study, by replacing hard corn flour with soft corn flour (with percentages of 0%, 30%, 50% and 70%), glucose syrup was produced and the effect of corn flour substitution ratios on the sensory properties and colorimetric parameters of glucose syrup obtained from these flour mixtures was investigated.

Materials and Methods

Materials

Samples of flint (hard) corn (*Zea mays var. indurate*) flour (Brazilian corn flour) and floury (soft) corn (*Zea mays var. amyalcea)* flour (Russian corn flour) were obtained from *Gandomkoub* Company, Iran. The characterization of flint (hard) and floury (soft) corns were as follows, respectively: Moisture content (10.5, 9.6 %), ash (1.7, 1.7 %), protein (10.3, 10.7 %), crude fiber (2.2, 2.2 %), fat (5.0, 5.4 %), carbohydrate (70.3, 70.4 %). All chemicals used were of analytical grade and obtained from Merck Co., Germany.

The commercially available enzymes used to produce glucose syrup were as follows: Glucoamylase (EC 3.2.1.3) from *Aspergillus niger* (Dextrozyme GA 1.5X, Novozymes, Denmark) (specific activity: 180 U/ml) at operating conditions (pH: 3.5-5 & temperature: 55-65 °C) and Alpha-amylase (EC 3.2.1.1) from *Bacillus licheniformis* (LIQMAX HT, ORBA, Turkey) (specific activity: 55 U/mg) at operating conditions including pH: 6-7 and temperature: 95-105 °C both of industrial grade.

Methods

Corn Flour Mixture Preparation

Treatments evaluated in this study were 4 individual mixtures including: 30% flint (hard) corn flour + 70% floury (soft) corn flour as treatment 1, 50% flint (hard) corn flour + 50% floury (soft) corn flour as treatment 2, 70% flint (hard) corn flour + 30% floury (soft) corn as treatment 3 and 100% floury (soft) corn flour as control.

Glucose Syrups Formulation

Calculated amounts of raw materials in preparation of glucose syrup formulations for 4 individual treatments were presented in Table 1.

Table. 1. Raw material calculated amounts in glucose syrup formulations.

Samples	Mixtures of Corn Flour (flint corn + floury corn)	Variable formulation components % (W/W)		Fixed formulation components % (W/W)		
		Floury (soft) corn flour	Flint (hard) corn flour	α-amylase	Glucoamylase	Water
Control	0 + 100	25	0	0.009	0.0009	74.99
1	30 + 70	17.5	7.5	0.009	0.0009	74.99
2	50 + 50	12.5	12.5	0.009	0.0009	74.99
3	70 + 30	7.5	17.5	0.009	0.0009	74.99

Preparation of Glucose Syrup

Preparation of glucose syrups was carried out according to the method described by previous study [15] with some modifications. The main procedure using different individual treatments and individual formulations (Table 1) with temperature and pH control is as following: preparing corn flour (pH: 5.8 and moisture: 14%) and water (60 °C) mixture, first step α-amylase addition (60 min), second step α-amylase addition (90 min), rotary filtration, glucoamylase addition (360 min), carbon active filtration, press filtration, vacuum evaporation which led to the production of concentrated glucose syrup (°Brix: 82.5).

Corn flour was first hydrolyzed by alpha-amylase (LIQMAX HT) and short chains of polysaccharides were produced. Second, glucoamylase (Dextrozyme GA 1.5X) breaks down the sugar chains more easily. One unit of enzyme activity was defined as the amount of enzyme that catalyzed the release of 1 µmol min^{-1} of reducing sugar as glucose at the optimal pH and temperature. The obtained syrups were purified through two separate steps.

Colorimetric Parameters Measurement

Colorimetric parameters evaluated according to colorimetric spectrophotometry method which was performed using a spectrophotometer (Infinite, M200 PRO, Tecan Austria, GmbH). To determine the appropriate wavelength to measure the absorption of syrup samples, first the absorption spectrum of the sample with 0.1 dilution in the wavelength range of 200-200-200 nm was drawn and it was observed that the syrup had three absorption peaks in the wavelengths of 230 , 285, 515 nm. Given that the visible color change of the sample is related to the visible region wavelengths of 700-460 nm, therefore the peak of 515 nm wavelength, which is located in the visible area, was determined as an indicator for measuring the absorption of the samples and the dye was introduced as an absorbent unit per milliliter of syrup. Color measurement of all samples was performed after their temperature equilibrium with ambient temperature [16].

Sensory Evaluations

Sensory evaluation was performed by evaluators. The scales based on the intensity of the properties, the equivalents of very low, low, medium, severe, very severe are examined by examining the parameters. The sensory evaluation form was submitted to the evaluators before the start of the work, and the features mentioned in the form were rated based on the intensity of the sense of characteristic perception. The appearance of the samples was scored based on the color, odor, taste and general acceptance of the sample, taking into account the pleasant mouthfeel, taste satisfaction and perceived pleasant feeling. For sensory evaluation, the samples were assessed organoleptically on the basis of flavor, aroma, appearance and general acceptance characteristics on a 5-point hedonic scale, ranging from 1 (dislike) to 5 (like) [14].

Statistical Analysis

The experiments were performed at least in triplicate via a completely randomized design. The results were correlated according to the nonparametric *Kolmogorov Smirnov* test (K-S Test). Analysis of the results (which were subjected to ANOVA one-way analysis of variance) was done using SPSS statistical software version 22 at probability value of 5% ($p<0.05$). The obtained results were expressed as means ± standard error and the mean significant difference was assessed using Duncan's multiple range tests.

Results and Discussion

Considering the importance of using glucose and fructose syrups in the food industry and the use of soft and hard corn flour mixture in the production of fructose and glucose syrup and also regarding to the importance of using corn flour in the production of these syrups, in this study, by replacing hard corn flour with soft corn flour (with percentages of 0%, 30%, 50% and 70%), glucose syrup was produced and the effect of corn flour substitution ratios on the sensory properties and colorimetric parameters of glucose syrup obtained from these flour mixtures was investigated. The results are presented as followings:

Glucose Syrups Colorimetric Parameter

Analysis of variance of effect of corn flour replacement (at levels of 30, 50 and 70%) on mean colorimetric parameters of glucose syrup treatments are presented in Table 2. Also Figure 1 depicts the effect of hard corn flour substitution (at 30, 50 and 70%) on glucose syrup color.

Table 2. Effect of corn flour replacement on mean colorimetric parameter of glucose syrup treatments. (Analysis of variance)*.

Variable	Source	Degree of freedom	sum of squares	average of squares	Test statistics	Significant levels observed
	Between groups	3	7610.25	2536.75	140.93	0.006
color	Within groups	8	144.00	18.000		
	Total	11	7754.25			

* Significance at the 5% level.

The results of analysis of variance (Table 2) showed that the effect of hard corn flour substitution on the color of glucose syrup was significant ($P\leq0.05$). The results of post hoc tests showed that there was a significant difference between the color of glucose syrup related to the control treatment and treatments containing 30, 50 and 70% of hard corn flour ($P\leq0.05$). The color of glucose syrup related to the treatment containing 70% of hard corn flour was significantly higher than the control treatments of 30 and 50% of hard corn flour ($P<0.05$). Also, the treatment containing 30% of hard corn flour was significantly different from the treatments of 50 and 70% of hard corn flour and the treatment of 70% of hard corn flour was significantly higher than the treatment containing 50% of hard corn flour ($P<0.05$). The highest color of glucose syrup was observed in the treatment containing 70% of hard corn flour and the lowest was observed in the control treatment.

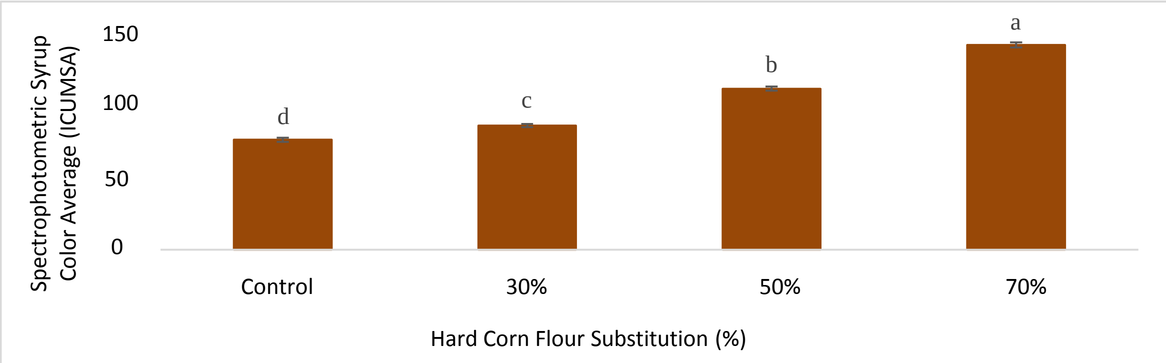

Figure 1. Color Parameter of glucose syrups obtained from different individual treatments.
Reported values are the means ± standard deviation of three replicates. Error bars indicate the maximum deviation from the mean values. Different letters represent significant differences in mean (P<0.05).

According to the obtained results, It was shown that substitution of hard corn flour in different percentages caused significant changes in syrups color (P<0.05). The color of glucose syrup increased with the addition of hard corn flour. The highest (140.33) and the lowest (75.33) amounts of syrup color were observed in 70% treatment (30% soft corn flour) and control (100% soft corn flour), respectively.

Maize or corn has various types (flour corn, flint corn, dent corn, sweet corn, popcorn, waxy corn, and amylomaize) and colors (ranging from white and yellow and red to purple) [11]. Since the structure of corn pigments has not been studied in detail, few studies have been performed on grains in this area [3]. One of the related studies is the evaluation and intuition of significant differences between anthocyanin and carotenoid compounds of maize. In the study of corn pigments, anthocyanins identified as water-soluble compounds and as a group of polyphenol flavonoids responsible for the red, purple, and blue colors in the body of plant plants such as fruits, flowers and leaves [8]. Where a group of sugars such as glucose, galactose, rhamnose, xylose, or arabinose are present in association with an aglycone, anthocyanins naturally form glycosides [4]. Evidence suggests the possibility of converting flavonols to anthocyanins by reducing their homologous glucosides which impact the color of final products [8].

Color parameters are unstable in the presence of oxide and reduction reactions, and this effect is intensified in the presence of reducing sugars, ascorbic acid, and acids. Therefore, any chemical reaction that can break the double bond of nitrogen in the color compounds will cause the color of these compounds to disappear [6,8,14].

Turbidity in glucose syrups is an important factor and the lower the turbidity, the more customer-friendly and marketable it will be [3,5]. Unlike sucrose, fructose and glucose are inextricably linked to fructose syrup, which is why they are more involved in browning reactions and intensify coloration [1,3]. Heating of glucose and fructose sugars intensifies the production of hydroxyl-methyl furfural, thereby increasing colorimetric indices [11].

The increase in browning and the color of the syrups is more pronounced with the increase in the ratio of hard corn flour, due to the increased acidity and lower pH in the hard flour samples [6,12]. Occasionally an increase in the amount of ash and minerals can also increase the amount of dye in glucose syrups [2,8].

On the other hand, the pigment content of hard corn flour is higher than that of soft corn flour because in hard corn flour, pigments stick to the starch and increase the color of the syrup, while in the corn flour the pigments are easily separated from the starch [6,14]. So that, depending on the type of glucose syrup used and the total starch hydrolysis, bleaching is essential. In addition to the separation of dye compounds, the separation of dye-producing materials is also important for increasing the shelf life of the product during storage without creating opacity and color [6,12,14].

Glucose Syrups Sensory Evaluations

The results of analysis of variance and post-hoc test (LSD) related to the effect of corn flour replacement on mean organoleptic parameters of glucose syrup treatments are presented in Table 3. Also Figures 2, 3, 4, 5 and 6 depict the effect of hard corn flour substitution (at 30, 50 and 70%) on glucose syrup falvor, aroma, appearance, visual color and overall acceptability, respectively.

Table 3. Effect of corn flour replacement on mean organoleptic parameters of glucose syrup treatments. (Analysis of variance)*.

Variable	Source	Degree of freedom	sum of squares	average of squares	Test statistics	Significant levels observed
Flavor	Between groups	3	2.91	0.972	3.88	0.055
	Within groups	8	2.000	0.250		
	Total	11	4.91			

ISSN- 2394-5125 VOL 8, ISSUE 01, 2021

Aroma	Between groups	3	1.000	0.333	0.667	0.596
	Within groups	8	4.000	0.500		
	Total	11	5.000			
Appearance	Between groups	3	2.91	0.972	3.88	0.055
	Within groups	8	2.000	0.250		
	Total	11	4.91			
Overall Acceptability	Between groups	3	2.91	0.972	3.88	0.055
	Within groups	8	2.000	0.250		
	Total	11	4.91			

* Significance at the 5% level.

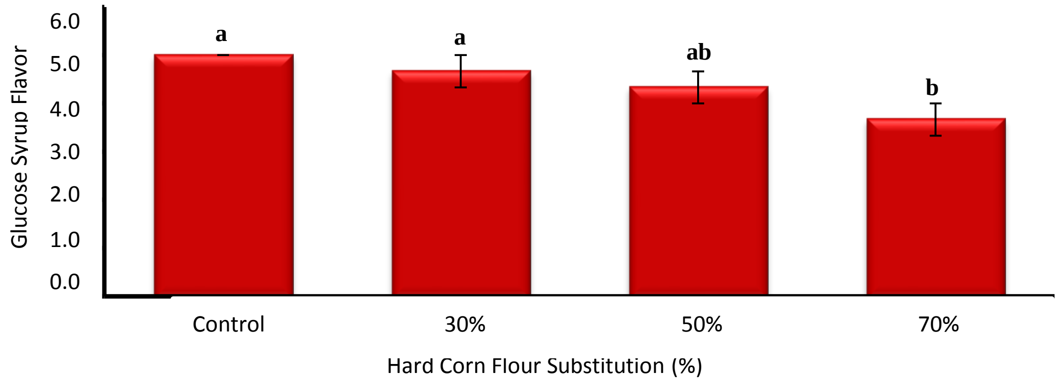

Figure 2. Effect of hard corn flour substitution (at 30, 50 and 70%) on glucose syrup falvor.
Reported values are the means ± standard deviation of three replicates. Error bars indicate the maximum deviation from the mean values. Different letters represent significant differences in mean (P<0.05).

Figure 3. Effect of hard corn flour substitution (at 30, 50 and 70%) on glucose syrup aroma.
Reported values are the means ± standard deviation of three replicates. Error bars indicate the maximum deviation from the mean values. Different letters represent significant differences in mean (P<0.05).

ISSN- 2394-5125 VOL 8, ISSUE 01, 2021

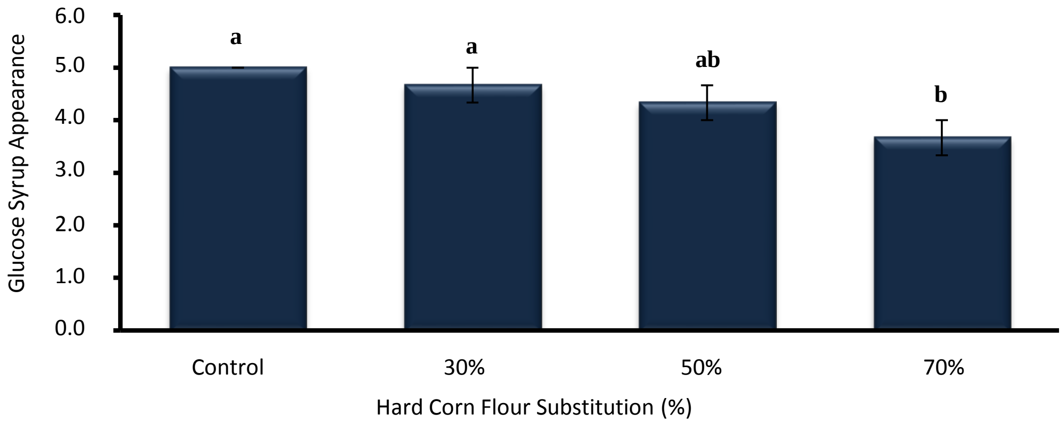

Figure 4. Effect of hard corn flour substitution (at 30, 50 and 70%) on glucose syrup appearance.
Reported values are the means ± standard deviation of three replicates. Error bars indicate the maximum deviation from the mean values. Different letters represent significant differences in mean (P<0.05).

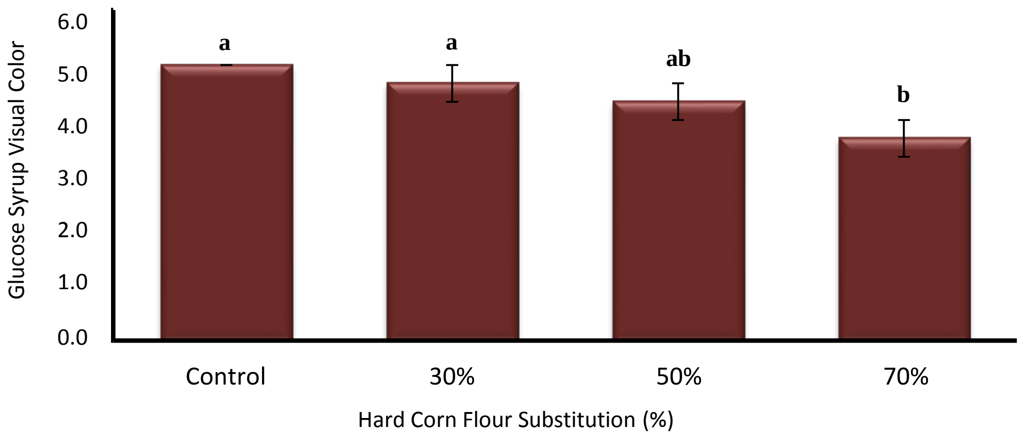

Figure 5. Effect of hard corn flour substitution (at 30, 50 and 70%) on glucose syrup visual color.
Reported values are the means ± standard deviation of three replicates. Error bars indicate the maximum deviation from the mean values. Different letters represent significant differences in mean (P<0.05).

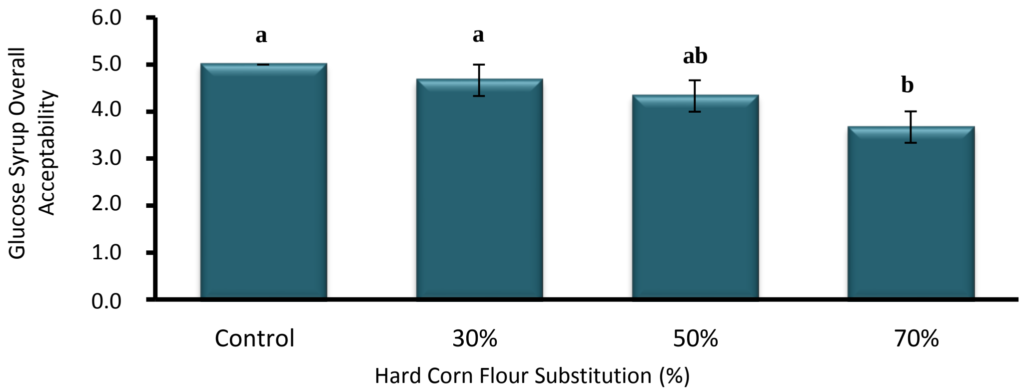

Figure 6. Effect of hard corn flour substitution (at 30, 50 and 70%) on glucose syrup overall acceptability.
Reported values are the means ± standard deviation of three replicates. Error bars indicate the maximum deviation from the mean values. Different letters represent significant differences in mean (P<0.05).

The effect of replacing hard corn flour (at levels of 30, 50 and 70%) on the taste and flavor, aroma, appearance, visual color and overall acceptability of glucose syrup were investigated. The results of analysis of variance (Table 3) showed that the effect of hard corn flour substitution on all sensory property levels of glucose syrup were almost not significant ($P \geq 0.05$), except for treatment containing 70% hard corn flour. The results of post hoc tests showed that there were no significant difference between the levels of these properties of glucose syrup related to the control treatment and treatments containing 30% and 50% of hard corn flour ($P \geq 0.05$), but the those of glucose syrup related to the control treatment were significantly higher than those of the treatment containing 70% hard corn flour ($P<0.05$). Also, the level of glucose syrup sensory properties related to the treatment containing 30% of hard corn flour were significantly higher than the treatment containing 70% of hard corn flour ($P<0.05$). The highest levels of glucose syrup sensory parameters were related to the control treatment and the lowest levels of all parameters were related to the treatment containing 70% hard corn flour (Figures 2 to 6).

It can be observe that according to the results of analysis of variance and post-hoc test (LSD) (Table 3), the effect of hard corn flour substitution (30% and 50%) on glucose syrup organoleptic parameters including flavor, aroma, appearance and overall acceptability was not significantly different in comparison with the control ($P>0.05$).

But regarding to the treatment consisted of 70% hard corn flour, all the sensory parameters were significantly different from those of other samples ($P<0.05$).

Increasing higher amounts of flint corn flour had affected these parameters in the syrup and reduced them in the case of being probable. In this way, organoleptic parameters of the treatment with 70% flint corn flour were not approved by the evaluators. Also according to Figure 6, 70% replacement of flint (hard) corn flour reduced the overall acceptance (acceptability) of the obtained glucose syrup. Therefore, this treatment did not seem appropriate for producing glucose syrup.

Generally, glucose syrups are clear colorless and tasteless syrups with no smell and have a viscosity similar to liquid sugar [3,4].

According to a research [11], sucrose showed a 7% reduction in sweetness at the beginning of tasting, while fructose-rich corn syrup showed a 18% reduction. Of course this reduction occurs only at the beginning of tasting and then remains constant throughout. Another research [10] has shown that fructose can increase the fruity and sometimes acidic flavor of beverages. Research has shown that different sweeteners have different sweetening functions.

There is also an intensifying effect between different sweeteners and a mixture of sweeteners. Sweeteners have a different sweetness than the total sweetness of its ingredients [6]. An intensifying effect of between 20-25% between glucose and fructose and between 20-30% between glucose and sucrose has been observed [9].

Using flint corn leads to an increase in the fructose content of the syrups and is evaluated as less favorable due to their darker appearance, due to increased brown reactions which is due to reducing sugars [8,15]. Treatment with ion-exchange and activated carbon resins destroys any minerals, undesirable color and taste [6,10]. Therefore, it may be possible to control and inhibit the relatively altered color and taste in hard corn flour samples using auxiliary treatments [9,11].

Conclusion

Due to the fact that today the naturalness of the raw material is highly regarded by consumers and glucose syrup is used as a natural substance in many food processes, so products derived from natural materials with minimal processing operations are considered as natural. Therefore, glucose syrup falls into this category. Glucose syrup is one of the best sugar alternatives and due to its sweetness can be used in food, pharmaceutical and chemical industries for various applications. Considering the necessity and importance of using soft and hard corn flour mixture in the production glucose and fructose syrups and the impact of corn flour on the produced syrups properties, in this study, by replacing hard corn flour with soft corn flour (with percentages of 0%, 30%, 50% and 70%), glucose syrup was produced and the effect of corn flour substitution ratios on the sensory properties and colorimetric parameters of glucose syrup obtained from these flour mixtures was investigated. Sensory evaluation of glucose syrup obtained from the mixture of soft and hatd corn flour (prepared by hard corn flour substitution at 30, 50 and 70%) showed that different amounts of hard corn flour substitution had a significant effect on different sensory evaluation parameters (taste, color, appearance and general acceptance) and reduced them. Also, the color of the syrup was affected by different amounts of hard corn flour substitution and increasing the percentage of hard corn flour increased the amount of color in glucose syrup. In hard corn flour, the pigments stick to the starch, which increases the color of the syrup in the hard corn flour. According to the obtained results, it is possible to use hard corn in different replacement amounts less than 70% in terms of appearance and organoleptic characteristics in the production of glucose syrup. Also, glucose syrup obtained from soft corn flour, which has been replaced with less than 70% of hard corn flour, has the ability to become fructose syrup as a substitute for sugar in the food industry in terms of appearance and organoleptic characteristics.

ISSN- 2394-5125 VOL 8, ISSUE 01, 2021

References

[1] Gabarra, P. & Hartel, R. W. 1998. Corn syrup solids and their saccharide fractions affect crystallization of amorphous sucrose. Journal of Food Science, 63(3), 523-528.

[2] Silva, R. N., Quintino, F. P., Monteiro, V. N. & Asquieri, E. R. 2009. Production of glucose and fructose syrups from cassava (Manihot esculenta Crantz) starch using enzymes produced by microorganisms isolated from Brazilian Cerrado soil. Ciência e Tecnologia de Alimentos, 28-36.

[3] Moeller, S. M., S. A. Fryhofer, A. J., Osbahr, C. B. & Robinowitz, E. Council on Science and Public Health and American Medical Association. 2009. Effects of high fructose syrup. Journal of the American College of Nutrition, 28(6), 619-626.

[4] Forshee, R.A., M. L. Storey., D. B. Allison, W. H. Glinsmann., G. L. Hein., & D. R., Linebac. 2007. A critical examination of the evidence relating high fructose corn syrup and weight gain. Critical Reviews in Food Science and Nutrition, 47(6), 561-582.

[5] Yetti, M. 2007. Improvement of glucose production by raw Starch degrading enzyme utilizing acid-treated sago starch as substrate. ASEAN Food Journal 14 (2), 83-90.

[6] Aiyer, P.V. 2005. Amylases and their applications. Afr. J. Biotechnol, 4(13), 1525-1529.

[7] Berski, W & Ziobro, R. 2017. Pasting and gel characteristics of normal and waxy maize starch in glucose syrup solutions. Journal of Cereal Science, 79, 253-258.

[8] Kim, Y., Yoo, SH., Park, K.H., Shim, J.H., & Lee, S. 2012. Functional characterization of native starches through thermal and rheological analysis. Journal of the Korean Society for Applied Biological Chemistry, 55, 413–416.

[9] Parker, K., Salas, M., & Nwosu, V. C. 2010. High fructose corn syrup: Production, uses and public health concerns. Biotechnology and Molecular Biology Review, 5 (5), 71-78.

[10] Ramachandran, V., Pujari, N., Matey, T., Kulkarni, S & Rice, A. 2013. Enzymatic hydrolysis for glucose-A Review. International Journal of Science, Engineering and Technology Research (IJSETR), 2(10), 1937-1942.

[11] Al-Farsi, M., Alasalvar, C., Al-Abid, M., Al-Shoaily, K., Al-Amry, M. & Al-Rawahy, F. 2007. Compositional characteristics of dates, syrups and their by-products. Food Chemistry, 104, 943–947.

[12] Khatoon, S., Sreerama, Y. N., Raghavendra, D., Bhattacharya, S & Bhat, K. K. 2009. Properties of enzyme modified corn, rice and tapioca starches. Food research international, 42(10), 1426-1433.

[13] Zainab, A., Modu, S., Falmata, A. S & Maisaratu, A. 2011. Laboratory scale production of glucose syrup by the enzymatic hydrolysis of starch made from maize, millet and sorghum. Biokemistri, 23(1), 1-8.

[14] Van Der Maarel, M. J. Van Der Veen, B. Uitdehaag, J. C. Leemhuis, H. & Dijkhuizen, L. 2002. Properties and applications of starch-converting enzymes of the α-amylase family. Journal of biotechnology, 94(2), 137-15.

[15] Rosa, M. 2004. Glucose production from maltodextrins employing a thermophilic immobilized cell biocatalyst in a packed bed reactor. Enzyme and Microbial Technology, 34, 415–421.

[16] Ettalibi, M. & Baratti, J.C. 2001. Sucrose hydrolysis by thermo-stable immobilized inulinase from Aspergillus hawaii. Enz. Microb. Technol., 37, 513-519.